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TOPOGRAPHICAL AND ARCHAEOLOGICAL STUDIES IN THE FAR EAST

BY

J. G. ANDERSSON

To
Professor Bernhard Karlgren

Dear friend and colleague,

This volume of our Bulletin, the last one to be completed during my tenure of office as Director of the Museum of Far Eastern Antiquities, I wish to dedicate to you on the occasion of your fiftieth birthday, the 5th of October 1939.

You will find that it contains the very earliest of my field observations in China from the years 1914, 1918 and 1920—24, and also the last field notes that I was fortunate in being able to write down during that glorious summer of 1937, when travelling in the Sino-Tibetan borderlands. You will also note that both my first and my last field researches in that vast Far Eastern Empire, which I love to call my second fatherland, are devoted to my original line of research, geology and the history of the earth's surface. *On revient toujours à ses premiers amours.*

Besides, I feel convinced that my study of the Cenozoic deposits and the physiography of China led me one day to the Chouk'outien cave. And the Malan terraces, to which this volume is devoted, became the topographical guiding line along which I traced the terrace dwellers of T'ao Ho and Hsi Kang.

While I was digging my way from the substructure up to the prehistory of China, you were marching along your road to victory from the present down through the ages, beginning with the phonetics of the modern Chinese language, only to excavate deeper and deeper into the literary sources of the past, until your ingenious analysis resulted in the unravelling of the language spoken by the Chinese during the T'ang dynasty. On the threshold of a still more profound secret, the spoken language of the Chou, you turned to the study of the bronzes cast and treasured by those early empire-builders, and the outcome was that remarkable chronology of the bronze art of the early dynasties presented in your masterly treatise »Yin and Chou in Chinese bronzes».

Our Bulletin will in years to come tell the scientific world of new discoveries that you will make in the domain of Far Eastern archaeology. But just as I have here devoted this volume of the Bulletin to some architectural features of the old and venerable house in which the Chinese people live, so you may one day widen the scope of the Bulletin by interpreting the spoken language of the men who cast those strange bronzes which you have named Middle Chou.

It is pleasant to return to that patch of soil where you first used your spade. *Il faut cultiver notre jardin.*

I wish you every success.

Yours devotedly,

J. G. Andersson

INTRODUCTION.

In the summer of 1914, only a couple of months after my arrival in China, I was sent by the Minister of Agriculture and Commerce to investigate the future prospects of the famous coal mines at Chai T'ang in the Western Hills (Hsi Shan) of Peking, 60 km. west of the capital. Four years later, in 1918, I returned there accompanied by two members of the Geological Survey, Mr. Chu and Mr. Li, and together we undertook a survey of the coalbearing area on the scale 1 : 10 000. For the third and last time I returned to Chai T'ang in 1920.

On all these occasions I carried out, as a personal hobby, studies of the physiographic features of this valley, which are very striking and of far-reaching interest. That part of the topographic survey which was allotted to me contained the side-valleys of Ma Lan and Ho Tsun, where I found a most magnificent development of the physiographic stage, which I named the Malan stage.

When travelling to and fro from Chai T'ang through the Men T'ou Kou and Pan Chiao valleys I found there splendid evidence of a stage of renewed vertical erosion younger than the Malan period of sedimentation. This period of erosion I named the Pan Chiao stage.

In November 1919 I presented to the Ministry of Agriculture and Commerce a manuscript entitled »The physiographic development of the Chai T'ang valley». This manuscript was never published in full, but numerous extracts were made from it in Mr. Yeh's monograph »The Geology of Hsi -Shan or the Western Hills of Peking». Memoir No. 1. of the Geological Survey, 1920, where on pages 66—75 Mr. Yeh summarized, with quotations from my paper, the observations on the physiography made by me during my survey of part of the Chai T'ang area. My manuscript of 1919 contained among other data a fairly complete record of my observations on the mode of formation and origin of the loess, a chapter now partly superseded by the observations made by more recent students of that vast problem. On the other hand, my detailed observations on the T'ang Hsien and Malan land surfaces and on the Pan Chiao erosive stage may still be of such fundamental value — especially in the light of my observations on similar features in other parts of Northern and Western China — that I have here reproduced in full those chapters of my 1919 manuscript which deal with the T'ang Hsien, Malan and Pan Chiao stages, and these chapters are illustrated by the part of the Chai T'ang map surveyed by me and here reduced to the scale 1 : 20 000 (Map 1).

In the years following the Chai T'ang survey I had various opportunities of making observations on the physiographic features of Hsi Shan which corroborated my Chai T'ang observations. Specially important were the notes made

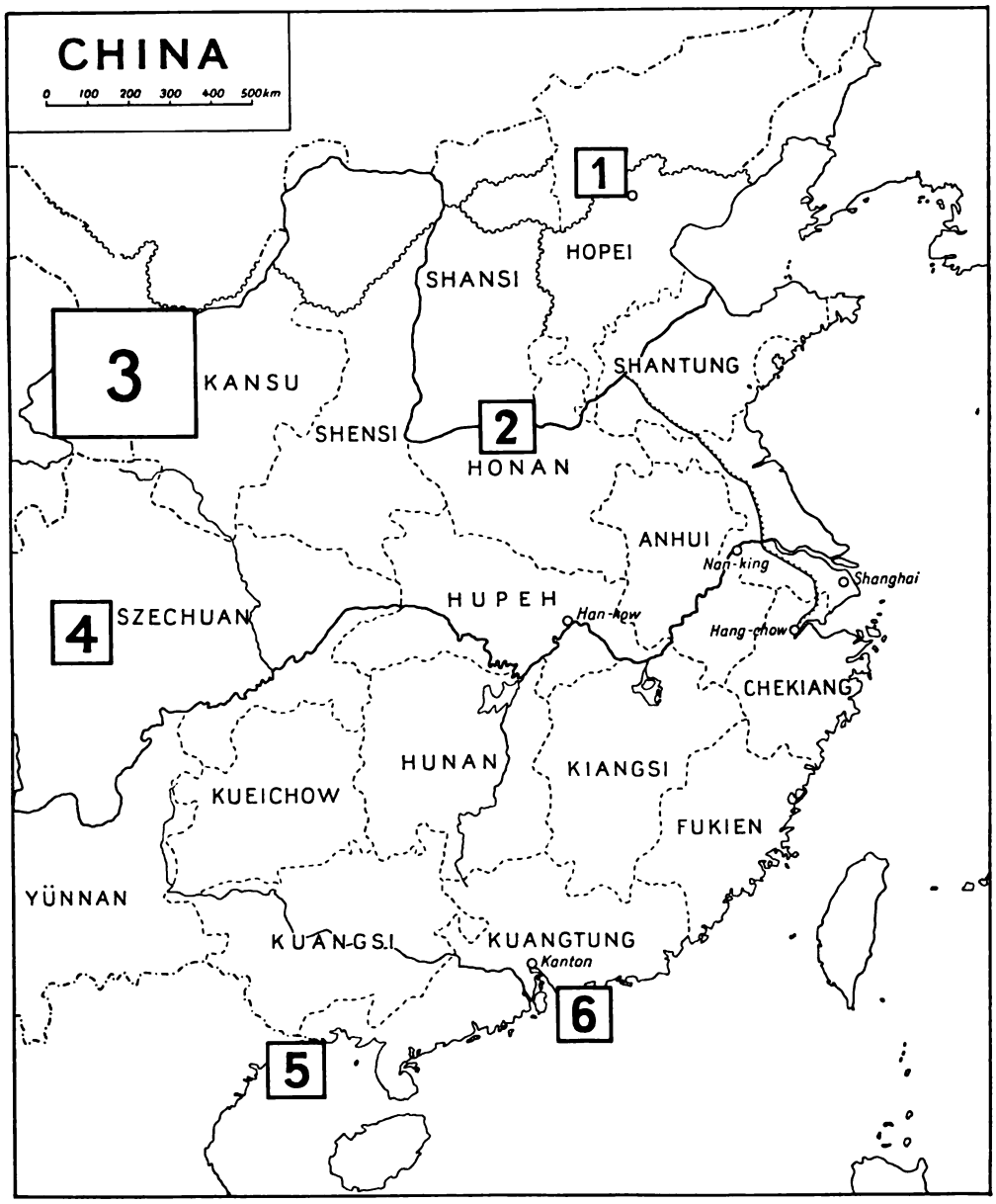


Fig. 1. Index map showing areas of research.

1. Hsi Shan or Western Hills of Peking.
2. Honan.
3. Shensi-Kansu.
4. Hsi Kang.
5. Tonkin, Fai Tsi Long.
6. Hongkong colony, Lantau Island.

during a rapid survey in September 1920 of the Hun Ho canyon between the Huai Lai plain and Ching Pai K'ou. These observations are recorded on pages 23—26 and illustrated by plates VIII—XII.

During my geological and archaeological studies in the province of Honan in the years 1916—1921 I had several opportunities of making observations on erosion in the once unbroken loess plain. These data, which are significant as showing that the erosion has partly taken place in early historical times, probably owing to afforestation, are recorded on pages 26—30 and illustrated by plates XIII—XVI.

In the years 1923—24 I undertook a journey to Kansu and the adjacent parts of Mongolia and Tibet, during which I had excellent opportunities of studying the terrace formations of the T'ao Ho and Sining Ho, as well as the magnificent gorge of the Huang Ho below Lanchow. These observations are here presented in a chapter entitled »Physiographic notes from Kansu». (Pages 31—44 and plates XIII—XX).

Thanks to these studies on the Malan terraces of Northern China, I was well prepared to cope with the magnificent terrace formations of eastern Tibet (Hsi Kang), which I was fortunate enough to study during the summer of 1937. But here I met with a phenomenon so far not encountered during my physiographic studies, namely, abundant traces of an extensive glaciation. The topographic studies in Hsi Kang thus became the climax of my physiographic researches in China, where I was enabled to determine the age of the Malan terraces and of the loess with reference to the maximal Pleistocene glaciation. These researches are recorded in the chapter »Glaciological and archæological research in Hsi Kang». (Page 45, plates XXI—XXXIV and maps 2—3). All the researches so far recorded form a continuous series leading up to the glaciological studies in Hsi Kang in 1937.

An independent study of a unique topographic region was carried out by me on the coast of Tonkin in the early part of 1938, and is here recorded under the title »Archaeological research in the Fai Tsi Long archipelago, Tonkin».

Another small isolated note is represented by the last article of this volume »The topography of the Shek Pek Site, Lantau Island, Hongkong Colony».

During recent years several members of the National Geological Survey of China, in collaboration with Professor Barbour and Professor Teilhard de Chardin, have established a more detailed physiographic chronology based upon an ex-

haustive study of the sediments underlying the loess. I have here found it necessary to refer to only one of these stages, the Sanmen stage, the determination of which has thrown much light upon the mode of formation of the series of sediments bordering the east side of the Hun Ho above its entrance into the Hsi Shan gorge.

In dealing with the glaciation of Hsi Kang I have made no attempt to correlate in detail my own field observations with those of other explorers working in the Nanshan alps, the Kuenlun range and the Himalayas. The time seems hardly ripe for fruitful correlations of this kind. Even the glaciological observations in Hsi Kang made by Loczy and myself in the course of rapid journeys have to be systematically revised by an expert on former glaciations. A good deal of time and the preparation of topographic maps will be needed for such research-work.

THE MALAN TERRACES OF NORTHERN CHINA.

THE PHYSIOGRAPHIC DEVELOPMENT OF THE CHAI T'ANG VALLEY.

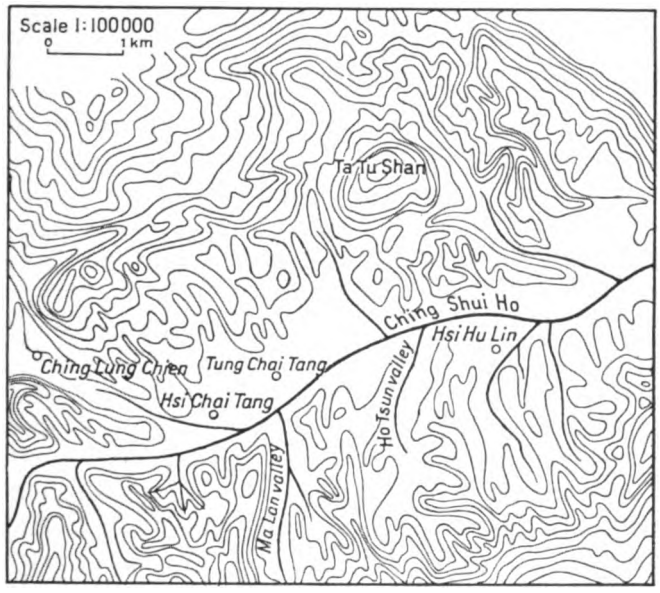


Fig. 2. The Chai T'ang valley. For details of the Ma Lan and Ho Tsun side-valleys see Map 1.

The T'ang Hsien land surface. On the south side of the main valley of Chai T'ang, on the edge of the dissected plateau SE and S from E, Chai T'ang village, there stand two conspicuous towers, well known to every visitor to that place (map 1). Both these towers are built upon the isolated remnants of an old gravel formation, which tells us an interesting story about the ancient valley of Chai T'ang.

At the eastern tower this gravel formation is of considerable extent — 450 m. in a NE—SW direction. The tower stands at a height of 196 m. and the contour

of the gravel runs SW along the 180 m. contour line, but sinks towards the NE near the 160 m. contour.[1] From these figures it may be concluded that the thickness of the gravel is in some places about 20 m., in some places somewhat more, in others less.

At the western tower the extent of the gravel is much smaller, only 100 m. and the tickness is also correspondingly reduced. At 198 m. the base of the tower stands upon a small patch of loess overlying the gravel.

Fig. 3. Chai T'ang. The slightly sloping T'ang Hsien erosion surface overlaid by T'ang Hsien gravels.

Between the two towers are two small patches of gravel, the one at 190 m., the other at a little above 180 m.

These accumulations of old gravel rest upon beds of the soft, easily crumbling green and violet shales (Chiu Lung Shan series) which are widely distributed in the Chai T'ang valley. The gravel is coarse with numerous pebbles as large as a fist or a head, and occasionally even larger. The petrological character of the pebbles is strikingly different from that of the bedrock underlying the gravel, as the pebbles mostly consist of the conspicuous red slaty rocks and coarse conglomerates belonging to the Chiu Lung Shan series as developed in the high mountains on the south side of the Chai T'ang valley.

A glance at the map will show that these patches of gravel are situated at the very edge of the dissected plateau facing the main valley, the flat bottom of which lies 130 m. below the gravel deposits. On the other side it will be observed that these small patches of gravel are evidently only remnants of an earlier, more continuous, gravel deposit that has been cut off by erosion from its source in the high mountains in the south.

We may sum up the above-mentioned facts as follows: The majority of the pebbles in these gravels are derived from the high mountains in the south; the present patches of gravel are cut off from these southern mountains by the deep dissection of the plateau, and the gravels so far mentioned are situated close

[1] All altitudes in this chapter refer to a local datum level, which is supposed to be about 200 m. above sea level.

to the precipitous slope of the plateau towards the main valley. It can then be inferred with certainty that the gravels are of considerable age and were deposited under topographical conditions radically different from those existing at present. First of all, it is evident that at the time when they were deposited the plateau had not yet been dissected but formed a plain connected with the Miao An Ling mountain by a gently rising slope. Moreover, the modern main valley did not exist at that time, but in its place the plateau extended across the recent valley

Fig. 4. Chai T'ang. The slightly sloping T'ang Hsien erosion surface overlaid by T'ang Hsien gravels.

to meet the corresponding table-land on the north side. The relation of the gravels to the present topography of Chai T'ang can be expressed thus: the gravels are older than the formation of the juvenile valleys of the region, such as the main valley (Ching Shui Ho valley) and its tributaries.

So far we have studied only a few gravel deposits near the edge of the southern plateau facing the main valley.

Proceeding 400 m. SSE from the western tower, we come across another small patch of gravel at a height of 212 m., and 250 m. further south still another at 224 m. These two spots lie within a 200 m. contour isolated from the higher ground in the south.

600 m. further SSE we meet the largest deposit of the old gravel found in the Chai T'ang valley, a lobated contour of 900 m. in length, and an adjacent smaller spot. Here, as in all other occurrences of this gravel, most of the pebbles consist of red slaty rocks and conglomerates of the Chiu Lung Shan series, as developed to the south side of the Chai T'ang valley. Owing to the proximity to the bedrock in the neighbouring southern mountain, the gravels here contain boulders as much as 2 m. in length. The material is entirely unstratified and the pebbles are loosely cemented by loamy material, the whole mass being somewhat reminiscent of a tillite. In fact, in the small path running across the hill I found some scratched stones, and somewhat surprised I started a search for striated stones in situ in the gravel. But the result was entirely negative, and after all I think there is no reason to doubt that the deposit is of purely fluviatile origin or formed by solifluction.

The deposit is about 15 m. thick in the highest hill, which is 293 m. in height. Fig. 4 shows this deposit, exhibiting the land surface of the T'ang Hsien stage as well as the gravel deposit resting thereon.

From the maximum altitude of 293 m. the gravel deposit sinks towards the N. down to about 170 m. This narrow lobe-shaped extension of the gravel deposit, ending just above the figure 166 m. of the map is a somewhat puzzling feature, as it seems very unlikely that the ancient T'ang Hsien landsurface reached down to so low an altitude in this place. But a close study of these old gravels reveals the fact that in some places the gravel has been redeposited during the period of vertical erosion which in a more recent time dissected the T'ang Hsien land surface, and it seems probable that this lobe of the gravel deposit may be such a secondary redeposit of a somewhat younger age. On the other hand it is decidedly older than the later stages of valley-erosion, as it now forms a ridge between two narrow valleys.

On the west side of the Ma Lan valley I have noticed one small patch of gravel capping the hill marked 265 m. It is here quite typically developed with pebbles mostly of red Chiu Lung Shan rocks.

I have now described all occurrences of these old gravels observed within the area surveyed by me. In every case the gravels occupy hill-tops or ridges, a feature clearly proving that, as already indicated, they were deposited upon an old land surface quite different from the present deeply dissected topography. In some rare instances it is possible to identify small remnants of this ancient land surface, as is the case in the hills reproduced in Pl. I. A small area of this »T'ang Hsien land surface» is also preserved in the porphyry-mountain on the west side of the Ma Lan valley in the plateau round the figure 312 M.

In most places this ancient land surface has been so dissected by subsequent erosion as to become almost imperceptible.

When standing on any dominant point of the dissected plateau, as for instance the hill 293 mentioned above, and looking towards the Miao An Ling we can easily detect at an altitude above 500—600 m., where the erosion has been much less powerful, large expanses of but little altered T'ang Hsien land surface. In fact, the highest parts of the mountain look like an almost continuous plateau with soft and gentle undulations of mature landforms. This undulating landscape, dominating above 700—800 m. begins at 500—600 m. to split up into sharp spurs and intersecting narrow ravines. At still lower levels, 200—400 m., we meet the comparatively dissected plateau mentioned above. When looking at a panorama such as that of Pl. I, background, it is, in fact, not difficult for the mind's eye to reconstruct the old Chai T'ang valley, a broad, flat valley bottom, some 200 m. above the bottom of the present main valley, connected by gently rising slopes with the undulating plateaus of the high mountains, the whole forming a landscape of advanced maturity, in which the bedrock was largely covered with coarse talus gravel washed down from the slopes of the high mountains.

My observations of these old gravels is practically confined to that part of the dissected plateau which is on the south side of the main valley. In 1914 I noticed on the top of a small hill to the north of W. Chai T'ang village a gravel or conglomerate deposit at 186 m., which may belong to this age.

It is probable that gravels of the type and age here in question have also been of common occurrence on the north side of the valley, as pebbles of the conspicuous red Chiu Lung Shan rocks are very abundant in the low-level gravels of Malan age, which occupy a considerable area, partly covered by loess on the north side of the two Chai T'ang villages. In no other way can I account for the appearance of numerous red Chiu Lung Shan pebbles in this place than by assuming that during the T'ang Hsien period the main river of the valley flowed further north than the present Ching Shui Ho and that gravels containing red Chiu Lung Shan pebbles were washed down by southern tributaries from the Miao An Ling to the mentioned places on the north side of the present valley. The presumed gravels of T'ang Hsien age situated probably at an altitude of about 180 m., were in the later period of vertical erosion redeposited in the gravel terraces of Malan age situated at an altitude of 100—140 m.

The Fen Ho stage of vertical erosion. At the end of the T'ang Hsien stage the Hsi Shan mountains everywhere exhibited the characteristics of advanced maturity: full rounded mountain forms, often broadening to undulating plateaus and connected by gentle slopes with open flatbottomed valleys. As already mentioned, these ancient land forms are now preserved only in isolated remnants, mostly in the high mountains. The wholesale destruction of this mature topography was caused by the inauguration of a new cycle of vertical erosion, the most important feature of which in Hsi Shan is the excavation of the canyon of the Hun Ho, the main river of this mountain tract.

The Ching Shui Ho, the main river of the Chai T'ang valley and a tributary to the Hun Ho, has likewise cut down its course to a juvenile valley, here broad and open, it is true, but still somewhat canyon-like owing to its steep sides.

Where the Chai T'ang villages are situated the modern valley is broad, 250—300 m., with flat bottom consisting of coarse gravel in which the river finds its way, largely subterraneous but here and there reappearing in branching, intricate streams. On the south side, at the two towers, the side of the valley rises abruptly above the recent riverbed as a steep cliff to 190 m. (130 m. above the gravel-plain of the river-bed). In this cliff the bedrock is everywhere exposed. On the northern side of the valley the land rises in a gentle but very irregular slope, dissected by numerous ravines, cut deep into the loess and gravel, which here largely cover the bedrock.

Further west the valley becomes narrower, with steep porphyry walls, as well in the north as in the south. E. from E. Chai T'ang the bottom of the valley widens to its largest breadth, but further east it again becomes more narrow. In this

eastern part it is walled in on both sides by fairly steep cliffs of the soft violet and green shales and the coal measures. The narrowing of the valley at Hsi Hu Lin is largely due to a loess-covered gravel terrace of Malan age, which occupies the greater part of the rock valley.

The cliffs forming the walls of the main valley in the north and south rise on an average 110—130 m. above the gravel plain forming the bottom of the valley. These figures indicate, then, the minimum depth to which the erosion during the Fen Ho time has cut down beneath the flat bottom of the ancient valley. But it must be kept in mind that the bottom of the recent valley is a gravel flat in which almost everywhere the water flows through gravel and only in a few rare cases near the side of the valley there is a stream running over an outcrop of the bedrock. This means that the actual rock-valley is somewhat deeper and its lower part hidden beneath the recent river gravel. The depth of this hidden part of the rockvalley is withdrawn from direct observation, but we may be justified in assuming that it is some few tens of meters deep and that consequently the total vertical erosion in the main valley during Fen Ho time amounted to something like 150 m.

What I have called above »the dissected plateau» is evidently only parts of the bottom of the ancient broad and flat valley of the T'ang Hsien stage.

During its course in the Chai T'ang valley the Ching Shui Ho receives several tributaries from the north as well as from the south, on the northern side one through the Ching Lung Chien valley, while two others come down, one from the west, another from the east side of Ta T'u Shan. On the south side there are tributaries in the Ma Lan and the Ho Tsun valleys. These small streams have cut into their valleys, beginning as narrow canyonlike ravines in the slope of the high mountains at an altitude of 500—600 m. and at their mouths passing into the main valley. At their entrance into the main valley these tributary valleys show all the characteristics of the latter as described above: steep cliff-like sides and a flat gravel-bottom hiding the actual rock-bottom to an unknown depth.

The old flat valley bottom of the T'ang Hsien stage has been cut up by the Ching Shui Ho and its tributaries into a number of plateau-like blocks with steep sides towards the valleys and a surface that is, as a whole, slightly sloping but in detail sharply dissected by an intricate system of small valleys and ravines. These blocks have been described above as »the dissected plateau». The hill-tops and ridges of these dissected blocks come very near to the ancient land surface of the T'ang Hsien stage but in the ravines between the ridges the erosion has cut down 50—100 metres, and in some cases even more.

The terraces of the Malan stage. The tributary valleys, such as the valleys of Ching Lung Chien, Ma Lan and Ho Tsun, exhibit a remarkable feature, namely enormous accumulations of gravel, forming terraces rising 30—40 m. above the recent valley bottoms.

The terraces of the Ma Lan valley are extremely well developed, and I have therefore proposed the term »Malan stage» for the period during which these gravels were accumulated.

Before I go on to describe in detail these young gravel deposits, it may be convenient to point out that their mode of occurrence is entirely different from that of the old T'ang Hsien gravels. These last-mentioned deposits are older than the present topography, as is proved by the fact that they occur as isolated rem-

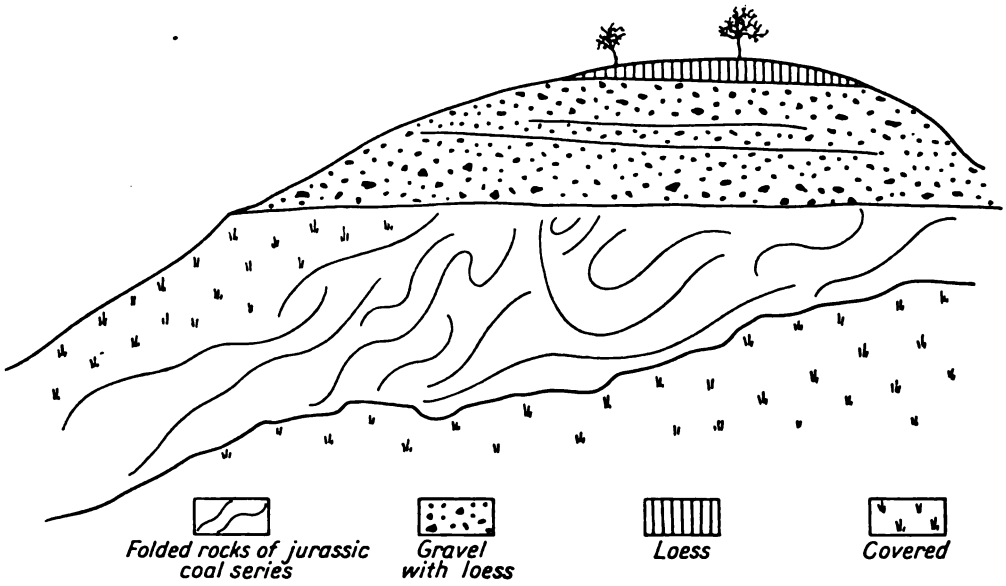


Fig. 5. Section in the main Chai T'ang valley at Hsi Hu Lin: Malan stratified gravels resting upon folded Jurassic and overlaid by loess. (See Pl. IV B and Pl. V A.)

nants on the hill-tops and ridges of the dissected plateaus. The young Malan gravels, on the other hand, are confined to the valleys of the Fen Ho stage. They often form extensive terraces, filling considerable parts of the valleys, and they are limited to an altitude of 30—40 m. above the present valley-bottoms. There are T'ang Hsien gravels as low down as 180 m. near the main valley, and Malan gravels as high as 243 m. in the uppermost parts of the tributary valleys. The absolute altitude is, then, no safe indicator of the age, but the relation to the surroundings will always prove whether a certain gravel-deposit belongs to the one group or the other.

The gravel terraces of the Malan stage were formed during a period of accumulation which filled the rock-valleys of the Fen Ho stage with deep masses of coarse-sediments; and their formation was followed by a new era of vertical erosion, the Pan Chiao stage, during which the Malan terraces were partly destroyed and dissected.

The big terrace of the Ma Lan valley is fully illustrated by map 1 and plate I. Seen from the mouth of the valley, the terrace forms a bold promontory, upon which stands a small pagoda, where the road to Ma Lan Tsun ascends the cliff of the terrace. I have measured the height of the terrace here and found it to be 36.3 m. calculated from the gravel plain of the recent river valley to the edge of the terrace plain. (Pl. IV A.)

The gravel is distinctly stratified with abundant fine material filling the spaces

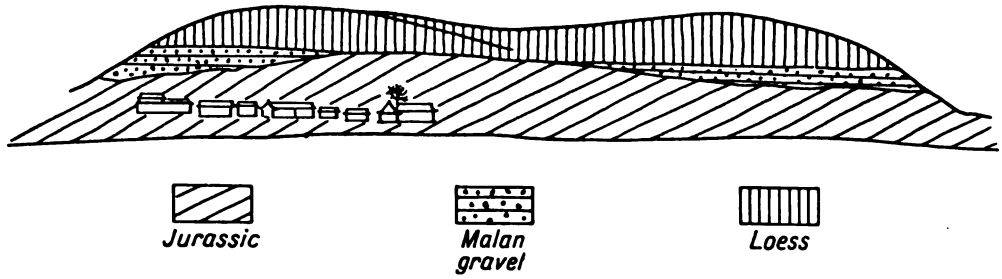


Fig. 6. Small hills in main Chai T'ang valley at Hsi Hu Lin, showing tilted Jurassic beds overlaid by Malan gravels and loess. (See Pl. V B.)

between pebbles. The size of the pebbles mostly varies between that of a walnut to the size of a fist, but boulders as big as a man's head are very occasionally seen.

The plain of the terrace is cultivated all over, and the stonewalls built by the farmers run across it, as shown by Pl. I with a regularity that adds to the striking appearance of the terrace. The terrace-plain looks nearly horizontal but, as proved by direct measurements, it gradually rises towards the upper part of the valley at approximately the same gradient as the modern bed of the Ma Lan stream.

At the small pagoda mentioned above the level of the terrace plain is 120 m.; 350 m. further south it is 124 m. and then follow in nearly equal distances 147, 163 and 186 metres as we proceed towards the upper part of the valley. The lastnamed figure, 186 m. represents a contour situated opposite the hill where a small patch of T'ang Hsien gravel is preserved at an altitude of 265 m. Between the two figures 163 and 186 m. we find at the west side of the valley, on the slope of the porphyry-mountain, two small patches of the gravel terrace, the one at a hight of 169, the other at 185 m., proving that the terrace once filled the Ma Lan valley from one side to the other.

In the upper part of the valley, near Ma Lan Tsun, the terrace is best preserved on the west side of the valley, and the altitudes 218, 223 and 243 m. have been measured for the edge of the terrace-plain. The lastnamed figure, close to the village, is the highest altitude at which Malan gravel terraces have been observed within the Chai T'ang area.

In the Ho Tsun valley we again come across a fine development of the terraces of the Malan stage. Opposite Ho Tsun village, close by the small village called Hsi Ho Tsun, there is a considerable area of the gravel-formation at about 100 m., much dissected by later erosion.

About half a km. south of Ho Tsun village the valley becomes narrow and makes a sudden bend to the E. It then again changes its course to south and further on to SSW. At the mentioned narrow bend there begins a new large area

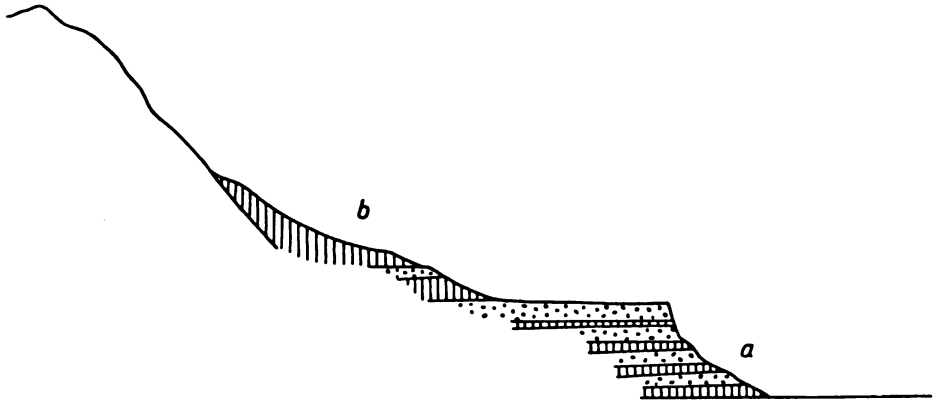


Fig. 7. Chai T'ang, Hsi Hu Lin. Section showing Malan gravels (a) overlaid by loess (b).

of the gravel-terrace which from there extends for more than a km. as a cultivated field forming the western side of the valley. (Pl. III A). To the eye this terrace-plain looks nearly horizontal, just as the Malan terrace does, but the survey has revealed that it slopes at approximately the same gradient as the valley itself. At the northernmost promontory we measure the figures 125 and 134 m. Further south, in gradually rising sequence, they are 146, 150, 161 and 177 (172) m. Opposite this continuous broad terrace, at the east side of the valley, there are three small patches of gravel terraces, and the altitudes on this side coincide strikingly with those on the other. Thus the altitude of the first small terrace patch, 140 m. corresponds to the figure 134 on the opposite big terrace. Further along, 151 m. E. corresponds to 150 m. W., and in the innermost part of the surveyed area, at a new sharp bend of the valley, a small terrace patch at 178 m. corresponds to 177 (172) m. on the opposite side.

These figures prove better than anything else that the big terrace plain of the west side and the three small patches to the east once formed part of one continuous vast sheet of gravel filling the whole valley.

Further E., on the south side of the main valley, I noticed the Malan gravel-terrace, but I had no opportunity of completing the detailed survey of this area.

The altitude of the terrace is here about 80 m., being in fact the lowest place where Malan gravels have been noted in the Chai T'ang valley. In this place the gravel is covered by a most conspicuous deposit of loess, which seems to indicate that the loess deposition in this instance at any rate, is later than the formation of the Malan gravels. The place needs a much more careful examination than has hitherto been given to it.

When we now turn from the south to the north side of the main valley we meet in one of the northern tributaries, the Ching Lung Chien valley, a fine occurrence of the Malan gravels. It is shown in Pl. II and Pl. III B and its altitude is 140—120 m. It forms a conspicuous terrace plateau rising to form a steep cliff (Pl. III B) 35 m. above the recent river bed. It is built up of distinctly stratified gravel with intercalations of loess-like material. In this interesting exposure there is nowhere any bedrock visible at the bottom, but the gravel extends everywhere down to the level of the recent riverbed. The surface of the gravel-plateau is cultivated, as in the Ma Lan and Ho Tsun valleys, and in the same way slopes gently down the valley.

At Ching Lung Chien village there is, at an altitude of 180 m. a gravel-terrace which certainly belongs to the Malan stage. The grade between this terrace and the one just described, about one km. further down the valley, is approximately the same as that of the more continuous terraces in the Ma Lan and Ho Tsun valleys, and the type of the Ching Lung Chien terrace is quite similar to the Malan type.

To the north of the two Chai T'ang villages we find a deeply dissected topography, where the predominant sediment is gravel covered with loess. Only locally does the bedrock, belonging to the violet and green series, become visible. These gravels differ from the typical Malan gravels in so far that, as has already been mentioned, they contain abundant quantities of pebbles of the red Chiu Lung Shan rocks. The occurrence of these pebbles of undoubtedly southern origin might possibly be interpreted as indicating that the gravels here in question belong to the old T'ang Hsien gravels. A small patch of high-level gravel situated some 400 m. NW. from W. Chai T'ang at an altitude of 186 m. has already been described as belonging to the T'ang Hsien gravels. But the gravels here in question occupy a much lower level. At W. Chai T'ang they occur at 120—100 m. and one km. east of E. Chai T'ang at 100—80 m. Opposite this extensive area of low-level gravels, on the north side of the main valley, we find on the top of the southern cliff the T'ang Hsien gravels at an altitude of 196—198 m. Even if the river of the T'ang Hsien stage had flowed further north than the recent Ching Shui Ho, there could not be such a large difference in altitude between the gravels of the T'ang Hsien stage. 186 m. on the north side corresponds very closely to 196—198 m. on the south side as indicating the corresponding altitudes of the T'ang Hsien gravels, but the 120—80 m. gravels on the north side must certainly be referred to the much more recent Malan gravels. If I am not mistaken, there are in the

low-level gravels numerous intercalations of loess-like material, which is, as far as my experience goes, never the case with the old, probably Pliocene sediments to which I am inclined to refer the T'ang Hsien gravels. The occurrence of numerous red Chiu Lung Shan pebbles may best be accounted for by assuming that high-level gravels of T'ang Hsien age were once abundant in about 180 m. altitude on the north side of the present main valley, and that during a later period of erosion these old gravels were largely destroyed and the material redeposited in the low-level gravels of Malan age.

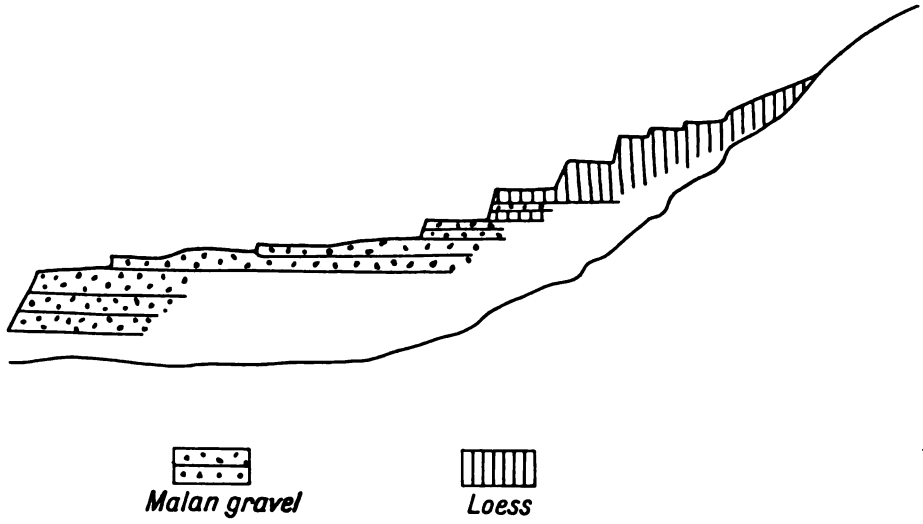


Fig. 8. Chai T'ang, Ta T'u Shan. Section showing Malan gravels overlaid by loess.

The Pan Chiao stage of vertical erosion. When we look at the fine terrace scenery of the Malan valley as exhibited by Pl. I we observe that on each side of the central terrace there runs a modern river valley, bounded on one side by the terrace and on the other by the bedrock slopes of the surrounding high mountains. The modern valley occupied by the small Ma Lan river is beautifully illustrated in Pl. I, and the other modern valley occupied by the little stream coming down from Ho Yang P'u is indicated in the same plate behind the terrace and is more clearly shown on the map.

Here the conditions are so simple and so easily interpreted that only a few words will suffice. It is evident that the different stages of development were as follows:

1. The vertical erosion of the Fen Ho stage cut down a rock valley considerably below the level of the recent river-beds.

2. Sediment accumulation during the Malan stage filled the rock valley of the Fen Ho stage with gravels to a height indicated by the gently sloping surface of the Malan terrace.

3. A more recent stage of vertical erosion, here called the Pan Chiao stage, has cut the modern river valleys but has not reached down to the bottom of the rock-valley of the Fen Ho stage.

The conspicuous feature of this last stage of vertical erosion is that it has so far effected only a partial removal of the Malan gravels. If the base of erosion were extended downwards, the recent rivers would not only deepen their course but at the same time laterally cut away more and more of the central terrace until it were completely consumed and the two rivers would meet in a central course, approximately coinciding with the course of the river occupying the Ma Lan valley during the Fen Ho stage.

A fact that apparently contradicts this interpretation is an observation made at the figure 124 m., 400 m. south of the northernmost promontory of the terrace. Here the modern Ma Lan river valley is very narrow and solid bed-rock seems to form the bottom of the recent river-bed. This could be interpreted as evidence that at this spot at least the erosion has reached down to the level of the Fen Ho stage. But in my opinion this observation has quite a different explanation, namely that a projecting resistant body of the gravel-terrace has forced the river temporarily to take its course over the bed-rock at the west side of the valley. This is undoubtedly a phase of but short duration. One day the river will overcome the resistance offered by the gravel and follow a course nearer the centre of the valley.

I know from my own country, Sweden, certain instances in which the enormous deposits of the Ice Age have filled pre-glacial river-valleys to such an extent that the rivers, when they again began to flow after the retreat of the ice-sheet, were forced by the glacial sediments to take an entirely different course in a newly-cut rock-channel. Such cases of rivers locally »losing their way» must not be considered as affording proof of local earthmovements, but simply as a temporary change of the river-channel due to the abundant filling up of sediment in the old rock-valley.

A second instance of such a median gravel-terrace due to the partial removal of the Malan gravels is met with in the Ching Lung Chien valley in the conspicuous gravel-deposit described above and situated one km. northwest from W. Chai T'ang. Here a bold gravel-promontory is situated between the Ching Lung Chien valley to the southwest and a much smaller tributary valley to the northeast (Pl. II and III B). Here too a continuance of the erosion would reduce the median terrace and establish a junction of the two streams higher up in the valley.

In the Ho Tsun valley we find much the same evidence of recent vertical erosion, the streams having cut down their channels in the gravels of Malan age 20—30 m. below the surface of the Malan terrace. 700 m. south of Ho Tsun village there is a truncated median lobe of the terrace between the main Ho Tsun valley and a small tributary, indicating, as in the other valleys, that the removal of the Malan gravels has as yet been only partially effected.

In the main valley the recent river-bed at the Chai T'ang villages forms a level

gravel-flat, 250—300 m. broad, through which the Ching Shui Ho flows in many intricate streams, partly at the surface, but largely through the gravel. The rock-bottom of the valley is evidently hidden at a depth of some tens of m. underneath this modern gravel flat.

Further east, at Hsi Hu Lin, the main river is much narrower, but nowhere, so far as I observed, is the bed-rock exposed at the bottom of the valley. On the contrary, everywhere in the Chai T'ang basin the recent erosion has only partially

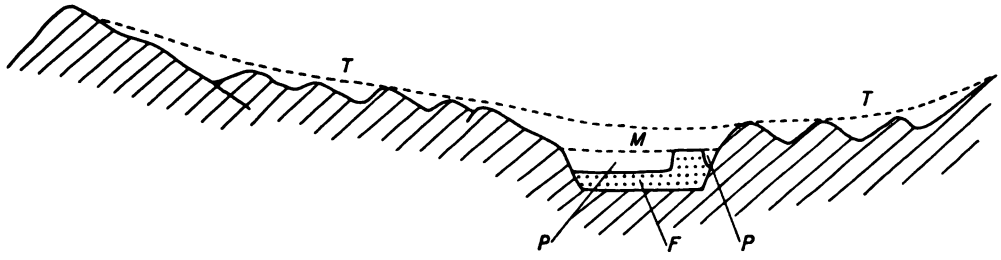


Fig. 9. Physiographic development of the Chai T'ang valley.

T = T'ang Hsien land-surface. M = Malan valley surface.
F = Canyon of Fen Ho stage. P = Pan Chiao erosion.

removed the sediments accumulated in the valleys during the Malan stage, and consequently the recent rivers generally flow over gravel beds, and only in a few rare cases over exposed bed-rock.

At the mouth of the Ma Lan valley some low terraces can be seen, as shown in Pl. I. These low terraces, 7—12 metres above the recent river bed, are cut in the bed-rock, here consisting of the violet and green shales, and may be regarded as intermediate stages between the Malan terrace and the present river bed, indicating temporary pauses in the deepening of the base of erosion in the course of which the lateral erosion has cut terraces in the rockslopes.

In order to give a fuller description of the latest physiographic development in these regions I must record some observations made outside the Chai T'ang area, when I was en route from Peking to Chai T'ang.

The Pan Chiao valley. This is a straight and narrow rock valley, half way between Chai T'ang and Men T'ou Kou, running approximately W—E from Lü Chia Tsun to Ching Shui Chien. In this area I could not recognize any features which can with any certainty be referred to the mature land-formations of the T'ang Hsien stage. It seems that the vertical erosion of the Fen Ho stage has so radically affected the topography in this region that the whole valley in its present shape must be interpreted as a product of the Fen Ho stage of erosion.

A remarkable feature of the Pan Chiao valley is a narrow modern rock-canyon cut down into the bottom of the main valley, which I have interpreted above as a product of the Fen Ho stage. Pl. VI affords a good idea of these conditions, which are furthermore illustrated by figures 10—12 in the text. The features of the main valley are steep slopes, terraced for cultivation at the base but higher up exhibiting the bed-rock or coarse talus masses. The bottom of the valley consists of a thin cover of gravel and loess, everywhere cultivated.

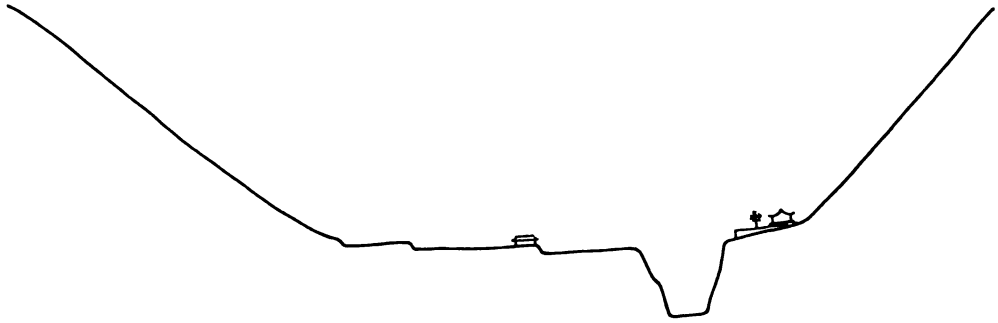


Fig. 10. Hsi Shan. Pan Chiao. Canyon of Pan Chiao stage. (See Pl. VI B.)

In this valley bottom of the Fen Ho stage a new cycle of vertical erosion has cut down a rock-canyon which is clearly shown in Pl. VI and fig. 10—12. This canyon has cut through the thin sediment cover of gravel and loess and is for the most part excavated in the solid rock, being in all essentials a veritable rock-canyon, evidently of quite recent origin.

I had no time to undertake a detailed survey of this recent rock-canyon, which is certainly worth closer examination. Its depth was estimated at 20—30 m. and that of a niche-shaped side-canyon at 15 m.

Its continuation eastwards and its junction with the large Hun Ho canyon remains an interesting object of future research.

The Men T'ou Kou valley. This is a valley E. of Pan Chiao at the edge of Hsi Shan towards the plain. The upper part of the Men T'ou Kou valley, as seen from the mountain pass at Feng K'ou An, exhibits a topography closely resembling that of the Pan Chiao valley. The valley as a whole must be regarded as a product of the Fen Ho stage erosion, with few undoubted traces left of the older T'ang Hsien topography. In this valley a more recent cycle of vertical erosion has cut a narrow rock-canyon, in which the village of T'ien Chao Fu is located. The walls of this canyon are estimated to be at least 30 m. high.

Further E. at the Tung Hsing colliery the aspect of the valley is somewhat different. Here the recent erosion has cut, not into solid rock but into a gravel formation, which once evidently filled the entire width of the valley bottom.

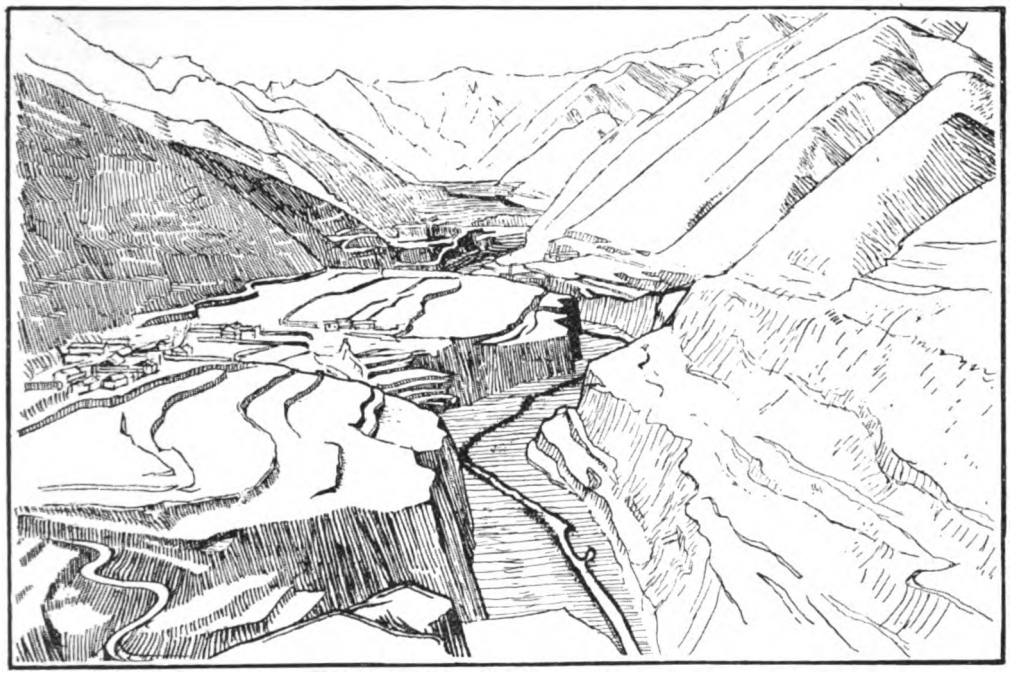


Fig. 11. Hsi Shan, Pan Chiao. Malan valley-plain dissected by formation of Pan Chiao canyon.

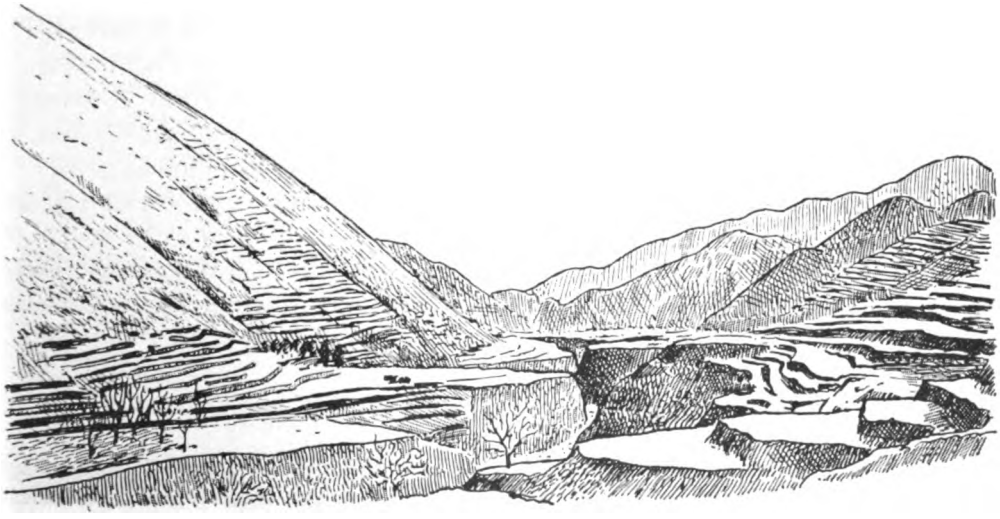


Fig. 12. Hsi Shan, Pan Chiao. Malan valley-plain dissected by formation of Pan Chiao canyon.

On the south side the gravels have largely been washed away, and here the recent stream meanders in a broad river-bed. On the north side the buildings of the Tung Hsing colliery stand upon a terrace which faces the present river-bed with a cliff 30—40 m. high. The material in the terrace is angular and impure gravel with a groundmass of reddish clay.

* * *

Above I have tentatively brought together under the denomination the P'an Chiao stage various features of recent vertical erosion noticed in different parts of Hsi Shan. I am quite willing to admit that objections can be made to this generalization.

It might possibly be said that the rock-canyons of the Pan Chiao and the upper Men T'ou Kou valleys are not of the same young age as the recent valleys cut in the Ma Lan gravels of the Chai T'ang basin. These rock-canyons might perhaps be regarded as side-canyons to the large Hun Ho canyon, which in its main features was undoubtedly formed during the Fen Ho stage, and it could be argued that the same period of vertical erosion will cut a broad and deep canyon in the main valley and smaller canyons in the side valleys. These matters are certainly still open to discussion, but, in my opinion, the valleys of Pan Chiao and Men T'ou Kou show on the whole far greater resemblance to the revived topography of the Fen Ho stage than to the advanced maturity of the older T'ang Hsien stage. Besides, it should be observed that in the Men T'ou Kou valley a rock-canyon entirely of the Pan Chiao type gradually passes into an eroded gravel terrace, which bears a striking resemblance to the eroded Malan terraces of the Chai T'ang valley.

Provided that the generalisation here tentatively proposed is correct, we are confronted with a situation of considerable physiographic significance. During the most recent stage of vertical erosion the deepening of the base of erosion is in some places shown by rock-canyons and in others by the dissection of preexisting valley gravels. In one case these two facies are displayed in different parts of the same valley, rock-erosion in the upper part of the valley and gravel-dissection lower down.

It is premature to try to explain in detail these intricate processes, but it seems possible that they may be attributed to complex and irregular earth-movements of recent date in Hsi Shan.

SOME NOTES ON THE TOPOGRAPHY OF THE LOESS.

In plate VII I have given two views from one of the most typical loess basins of Northern China, the basin of Hsin Yao in Lung Kuan Hsien, in the mountains north of the Huai Lai plain. This basin which is, at least partly, of tectonic origin,

a »Graben» framed by faultlines, is, as shown by the beautiful photographs which have been kindly communicated by Dr. F. Tegengren, filled with a loess deposit. At the borders of the basin there are locally seen intercalations of gravel which have been washed down from the adjacent slopes during the period of loess deposition. But in the centre of the Hsin Yao basin the eolian loess is pure and unmixed, with considerable thickness exhibited in numberless ravines which are probably of relatively recent age and formed after the area was deforested. This is a typical case of the eolian loess filling a tectonic basin.

Another type of loess deposit we will learn to know in the chapter on Honan where the loess fills erosion channels in the Pliocene clays, channels which are entirely obliterated by the eolian deposit to such an extent that their existence is revealed only thanks to a quite recent cycle of erosion.

In the Chai T'ang valley the loess in rather scarce and occurs as local patches upon level ground as well as on hillslopes. Here the loess occurs in all kinds of localities from 350 m. altitude to near zero of our local survey (about 200 m. above sea level). It is met with at dominating points of the dissected plateau as well as down in the ravines cut in this plateau, and at the Chai T'ang villages and at Hsi Hu Lin it forms a cover over gravel-terraces of the Ma Lan stage.

A noticeable feature of the distribution of the loess is that it is much more abundant on the north side of the main valley than on the south side, what may be attributed to the effect of prevailing winds. In fact, when the Chai T'ang scenery is viewed from some dominant point by an eye accustomed to deposits of dry snow-drifts, as they occur in the polar regions, the similarity is most striking, and it can hardly be doubted that the loess deposited in the Chai T'ang basin is chiefly a winddrift deposit. Just as the snowdrift it is to a large extent deposited without regard to altitudes, settling down in every place, high or low where the local topography caused a slackening of the velocity of wind sufficient to allow the suspended snow or dust to go to rest.

In the Malan terraces there are frequent intercalations of loesslike beds, and consequently it seems as if the deposition of the loess had begun already when the Malan valley-plain was being formed. But on the other hand some of the deposits of pure and unmixed loess rest upon the Malan terraces, what seems to show that the main loess deposition took place upon the ready Malan valley-plain. The existence of a somewhat older deposit of stratified gravels and a slightly younger deposit of eolian loess we will in the following chapters trace all the way to northwestern China and from there southwards to Hsi Kang.

THE CANYON OF THE HUN HO.

Hun Ho, the main river of Hsi Shan, flowing not far to the NE of Chai T'ang is formed through the confluence of three streams, which flow, the Yang Ho from northwest (Kalgan), the San Kan Ho from west and the Huai Ho from east.

These rivers flow over the Huai Lai-Kalgan plain and meet not far above the entrance from the plain into the »Durchbruchsthal» to use the expressive German term, the deep canyon which the combined river, the Hun Ho, has cut through the ranges of Hsi Shan.

Pl. VIII shows the entrance of the river into the gorge. VIII A exhibits the entrance at Kuan Ting as viewed down river, and VIII B looking upriver, with

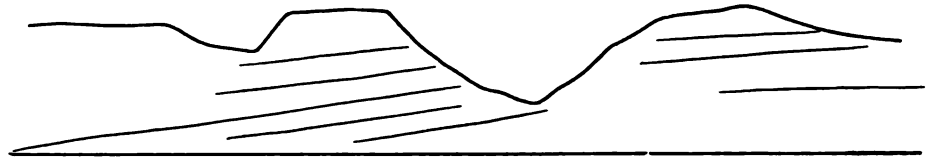


Fig. 13. Entrance of the Hun Ho into the canyon at Kuan Ting: Sanmen sediments dipping upriver.

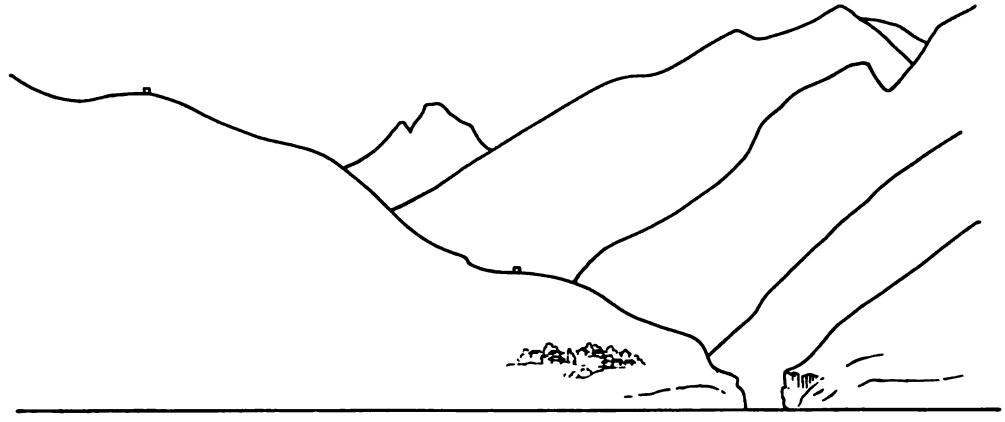


Fig. 14. Entrance of the Hun Ho into the canyon at Kuan Ting. (See Pl. VIII A.)

the Huai Lai plain and the distant mountains north of this plain seen far in the background.

The most startling feature which meets the geologist when approaching from the plain the mouth of the gorge is a series of stratified deposits (fig. 13) dipping away from the mountain in northern direction that means dipping *upriver*. At the occasion of my rapid survey of this gorge in September 1920 I got no opportunity to visit the east side of the river where this remarkable section is exhibited.

But the sedimentary series here in question became better understandable when the two French scientists Licent and Teilhard made in the valley of San Kan Ho the remarkable discovery at Ni Ho Wan of a late Pliocene or early Pleistocene fauna in a lacustrine basin, and when later Barbour in his work »The

geology of the Kalgan area», Mem. of the Geol. Survey of China No. 6, 1929, extended the new light thrown by the Ni Ho Wan discovery to the Hun Ho at Kuan Ting.

Because of the find made by Dr. V. K. Ting of a freshwater fauna below the loess at the Sanmen rapids in the Yellow river on the Shansi-Honan border there has been established a physiographic and palaeontological stage, the Sanmen stage, to which is counted the rich fauna of bivalves found by me at Ho Ti Tsun further down on the bank of the Yellow river (pl. XIII) as well as the rich Ni Ho Wan deposit. To this stage are also counted by Barbour the stratified deposits outside the entrance of the Hun Ho at Kuan Ting (Geology of Kalgan area, p. 103—104).

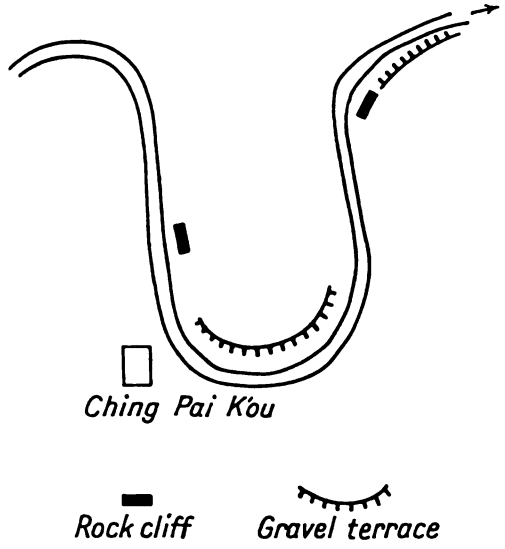


Fig. 15. Erosion cliffs and terraces at Ching Pai K'ou.

According to Barbour's interpretation the formation of these fluviatile or rather lacustrine deposits is due to slight warping causing local ponding of the rivers in question. In the case of the Hun Ho deposit (fig. 13) the dip upriver is so strong that it seems as if the beds were tilted after their formation. As the boundary line between the plain and the mountains is certainly a major tectonic line there is all likelihood for such a slight tilting in post-Sanmenian time.

In plate VIII we see the beginning of the canyon where the hills are still relatively low and the canyon consequently not very deep. Plates IX—XI represent the canyon at its full height, 300 metres or more, a gigant rift through the whole range, with steep slopes towards the whirling river. In this zone of the gorge there is hardly any trace of the old T'ang Hsien landsurface, everywhere are only the majestic steep slopes of the channel which the erosion has cut through the Hsi Shan ranges.

But there is a feature which should be specially emphasized. In all the four plates but most so in VIII and IX we will notice that the lower cliffs immediately rising from the riverbed to about fifty metres are perpendicular, whereas the upper parts of the canyonwalls are steep with occasional outcrops as shown specially well by Pl. IX.

It is evident that vertical cliffs like those seen on plates VIII and IX may have been formed merely through lateral meandering erosion at a constant level of the riverbed. But these perpendicular cliffs of the Hun Ho remind us in size and type strikingly of the small perpendicular gorges cut by recent deepening erosion

in the bottom of the old Fen Ho-stage valley of Pan Chiao where it is beyond doubt a case of a new cycle of vertical erosion. This possibility of a revival of the vertical erosion in the Hun Ho canyon is corroborated by observations in Kansu as we will see in the chapter on that province.

In the Hun Ho canyon gravel terraces were seen in several places. Plate XII shows such a terrace upon which is located the village Hsia Ma Ling. According to my aneroid reading the terrace is here 30 metres high.

A group of erosion cliffs and terraces indicating Pan Chiao erosion in the old Malan valley plain are shown in fig. 15 showing the conditions at Ching Pai K'ou.

In other places there are terraces in only 15—20 metres altitude.

LOESS EROSION IN HONAN

During the years 1919—1921 I visited several times that part of the Yellow River course which is bounded to the north by the province of Shansi and to the south by the province of Honan.

Very interesting contributions to the history of the Cenozoic were made in this region. Apart from the find of Eocene deposits at Yuan Chü in southernmost Shansi, the first scientifically recorded site of the early Pliocene Hipparion beds was found by me in the late autumn of 1918 at Shang Yin Kou in Hsin An Hsien, in Honan. The sediment is red and variegated clay with interbedded gravel.

A late Pliocene deposit of red clay could also be distinguished on certain sites, where mammal species proved the existence of a fauna much more recent than the Hipparion fauna. These Pliocene red clays were to the early observers, such as Richthofen and Bailey Willis, included in the loess, and thus gave rise to the exaggerated ideas about the thickness of the loess deposit. In fact there is clear evidence of a period of erosion between the Pliocene clays and the loess, which, as we shall see in the following, is filling up erosion channels cut in the clays.

But before we enter upon a discussion of this pre-loess erosion we should consider another series of sediments which underlies the loess everywhere in the valley of the Yellow River. During a boat journey from Tung Kuan to Shen Hsien in 1917 I saw below the loess in several places beds of sand and clay, and in some localities fossils, mostly freshwater shells, though mammal bones were also found. A first collection of these shells was made by V. K. Ting at the San Men rapids in 1918, and from this locality the whole series was named the Sanmen beds. Another richly fossiliferous site was discovered by me in 1921 at Ho Ti Tsun in Yuan Chü Hsien. Both these localities of Sanmen age were described in my paper »Essays on the Cenozoic of Northern China». Mem. Geol. Survey China. No. 3. 1923. P. 117—120. The Ho Ti Tsun section is again reproduced here in Pl. XIII and fig. 17.

In several localities, mostly in places high above the main river valleys, the substratum is not clay, sand and gravel of Sanmenian age (early Pleistocene)

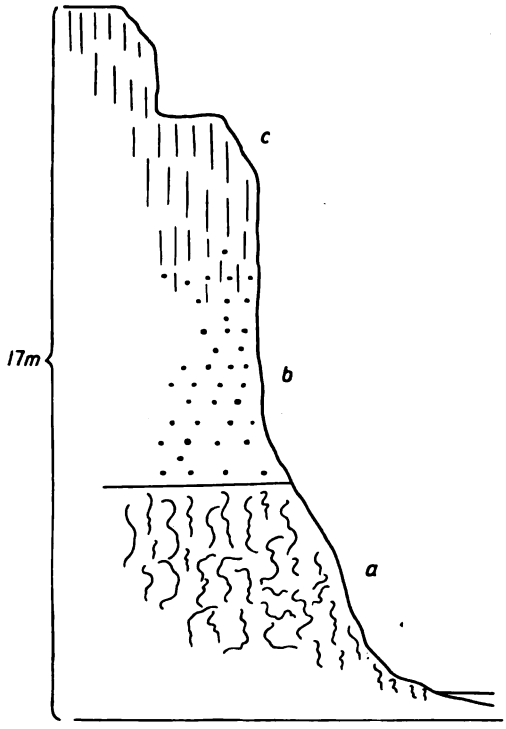


Fig. 16. Section between Hsin An Hsien and Shang Yin Kou.

a. Tertiary red clay with greenish-grey veins.
b. Gravel, matrix partly loess, partly red clay.
c. Loess.

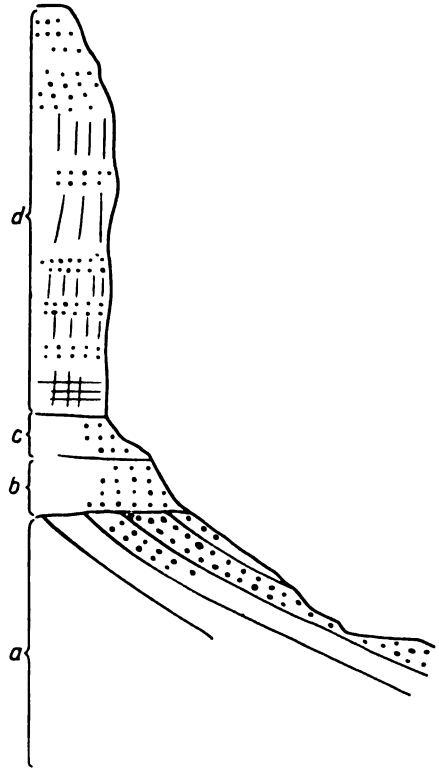


Fig. 17. Section cut by the Huang Ho at Ho Ti Tsun, Shansi.

a. Coarse Eocene conglomerate 17 metres.
b. Coarse gravel ..... 2,5 »
c. Gravel and sand mixed with gravel. In this hard packed sediment there are numerous huge freshwater mussels of Sanmen age ..... 2 »
d. Interstratified loess and gravel, about ..... 20 »

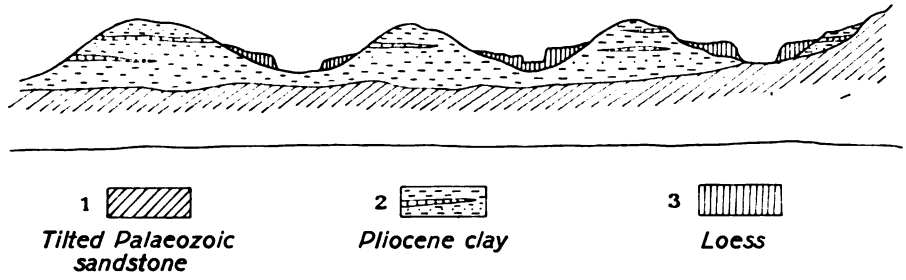


Fig. 18. Section showing relationsship between Pliocene clay and loess. Hsin An Hsien, Honan.

but Pliocene clays. For instance, near Shang Yin Kou in Hsin An Hsien (fig. 18) the loess occurs as the filling of small valleys cut into the Hipparion clays. There was a most marked period of erosion here before the loess settled down and obscured the pre-loess erosion-topography.

Similar conditions were noticed at Yang Shao Tsun in Mien Chih Hsien, the village now made famous by the find of the first Neolithic village. As shown by Pl. XIV—XV and fig. 19 in the text, here was a once continuous plain which has

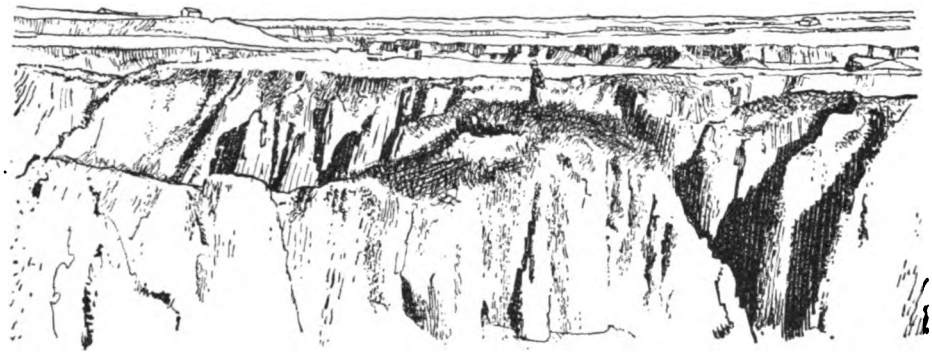


Fig. 19. Ravine erosion. Yang Shao Tsun, Honan.

been cut in post-Neolithic time by numerous ravines more than 40 metres deep. At first sight it looks as if the entire surface of the plain consists of the loess, but a closer inspection revals the fact that in the slightly higher fields between the ravines the Pliocene clay rises to the present land-surface. On the other hand, in the modern steep ravine cliffs there is a considerable, but very varying, thickness of loess above the Pliocene clay. These facts we can account for only by assuming that there existed in this area, just as at Hsin An Hsien, before the deposition of the eolian loess, a system of erosion channels which were once choked with loess and have been opened again by the recent erosion.

At the end of the deposition of the loess the channel of the Yellow River was entirely choked by the eolian deposit. The loess cliffs at Shen Hsien and other sites along the river show beyond doubt that such was the case: an undulating loess plain covered and obscured nearly alla topographic features earlier than the loess. The post-loess cutting of innumerable ravines in the sheet of loess, and locally also of small canyons in solid rock, we ascribe in the main to the stage which I have named Pan Chiao.

But the very detailed observations which I was forced to undertake of the prehistoric site of Yang Shao Tsun proved beyond doubt that in that case the cutting of the ravines is of relatively recent date.

At first glance it seems as if the ravine topography were older than the prehistoric village and that the site was chosen by the ancient Yang Shao dwellers

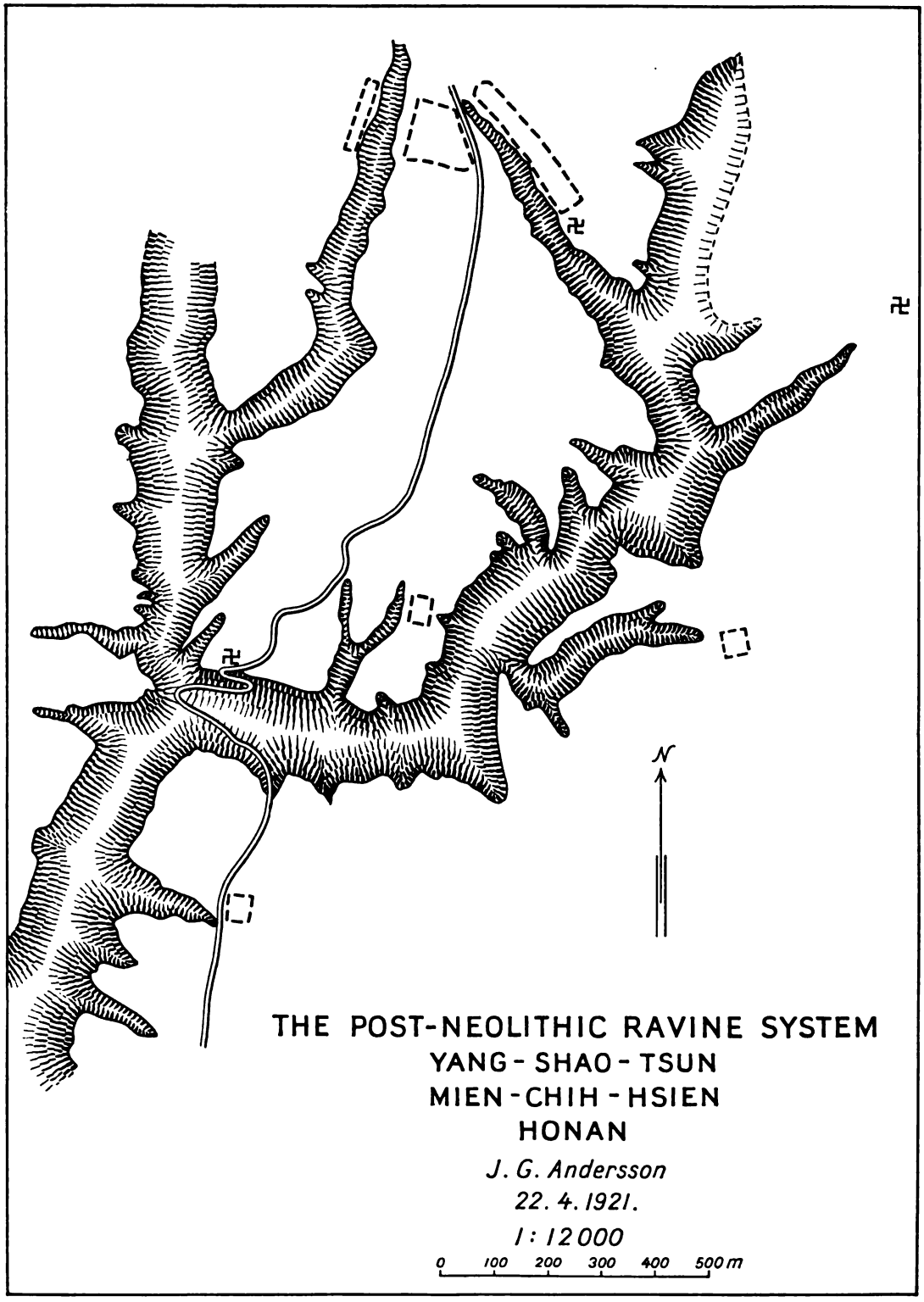


Fig. 20. Map showing ravine erosion, Yang Shao Tsun.

This map is only a rapid sketch which I made during the first reconnaisance at Yang Shao Tsun in April 1921. A much more detailed contourline map was prepaired by Mr. P. L. Yuan in the autumn of the same year during our excavating period at Yang Shao Tsun and will be published in my volume »Prehistoric Sites of Northern China». The sketch map, fig. 20, will suffice for the present purpose.

because the surrounding steep ravines formed a natural system of fortifications. Such was my view during the first few days of the Yang Shao survey.

But one day I found evidence pointing in quite a different direction. In several places within the site were found isolated loess pillars crowned by a cap of ashy earth, the typical sediment left by the prehistoric dwellers. It became evident that the cutting of the ravines had continued on into early historical times when the stone-age village had long ago been abandoned. In the southernmost part of the site (pl. XV A), in a little promontory upon which two men are standing in the photograph, I found a series, six metres thick and consisting of stratified sand and gravel, containing numerous artifacts of Yang Shao type, mostly pottery, but even such a delicate object as an almost complete sewing needle made of bone.

This deposit proves beyond doubt that during the Yang Shao time or slightly later there flowed over the nearly unbroken plain a stream carrying refuse from the site and depositing the assorted material in its course about forty metres above the level of the small stream that now flows at the bottom of the 40-metre deep modern gorge.

That the whole ravine system of Yang Shao Tsun was formed long after the site had been abandoned is further proved by observations made in the main ravine leading southwards from Yang Shao Tsun. Five km. further south, at a place named Kuan Chuang, there were encountered conditions similar to those just described and proving that this section of the ravine was also cut at a time more recent than the Yang Shao village.

Plate XVI shows two examples of erosion scenery from Meng Tsin Hsien, further east on the north side of the Yellow river. Here, too, deep and very narrow ravines are cut in the Pliocene clays and the superimposed loess. There is no direct evidence here that the cutting of the ravines is more recent than the Yang Shao culture, but the type of the gullies is very similar to the ravine system of Yang Shao Tsun.

We are now entitled to ask: why has the cutting of gullies in the soft Pliocene and Pleistocene sediments in early historical time been so intensive as is the case at least at Yang Shao Tsun? Everything goes to show that in prehistoric times the woods covered most of the land and that later the forests were cut down to yield firewood and to open up new fields for cultivation. In the now barren loess land, where there is no protection against the violent summer rains, the process of ravine-cutting is very active even at the present day.

The case of Yang Shao Tsun should not be regarded as typical of the topography of prehistoric sites. As we shall see in the following chapter on Kansu, several sites, as for instance the Hui Tsui site of the early Bronze Age, were actually located within a pre-existing ravine topography which afforded excellent protection to the Bronze Age dwellers.

Here, as in numerous other scientific problems, every case has to be tested on its own merits.

PHYSIOGRAPHIC NOTES FROM KANSU

From May 1923 until October 1924 I travelled in the province of Kansu and adjacent parts of Mongolia and Tibet. The main object of my research was archaeological excavations, but numerous notes on physiographic phenomena were taken in the course of my travels, some of them of fundamental importance for the proper understanding of the physiographic history of Northern China. These notes are published below, and as a matter of convenience I take them with one exception in the same geographic sequence as my journey proceeded.

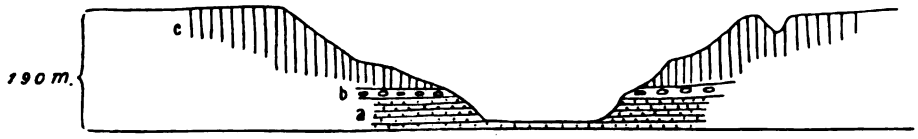


Fig. 21. Section across the Ching Ho, 7 km. below Pinchow.

a. Nearly horizontal sedimentary beds, probably young Palaeozoic.
b. Gravel, locally hardened into conglomerate.
c. Loess.

The valley of the Ching Ho. Ching Ho is a medium-sized river which flows from eastern Kansu southeastward over the Shensi plain and joins the Wei Ho north of Sian. 7 km. below Pinchow I noted down the cross section of the Ching Ho valley which is shown in fig. 21.

On both sides the river-valley is here bordered by the nearly level loess plain. The two loess escarpments on either side are so identical in height and general type that there can be no doubt that there was a continuous loess surface right across the present river-valley, where a post-loess erosion has cut down a juvenile valley to a depth of about 190 m. (aneroid measurement). It seems as if the loess had here a thickness of about 120 m., but for the reasons given below I think that this figure should be considerably reduced. Below the loess there is a gravel deposit, 10—20 m. in thickness, and these Pleistocene deposits rest upon a nearly horizontal sedimentary series of Palaeozoic (?) age and consisting of sandstone with shales. Into this series a rock canyon has been cut down approximately 50 metres in depth.

As this modern river-valley has been cut right through the loess deposit, which in this part of China attains its maximum thickness, the valley in its present shape must be taken to be of Pan Chiao age. The cutting of a juvenile rock canyon 50 metres deep is a quite astounding feat of the Pan Chiao stage.

Further up in the Ching Ho valley, 10 km. from Ching Chuan, I sketched the northern side of the river valley as seen in fig. 22. Here again we find the 50-metre high recent erosion cliff, but above it the topography is quite different from that of fig. 20. Here we find, above the erosion cliff, a nearly level terrace and beyond

that the loess plateau, gently sloping towards the river. This section has made me think that possibly the apparently enormous thickness of the loess in section 21 may be in need of reduction, as a pre-loess topography may possibly be hidden under the loess cover. Still, even if we assume that there was here in pre-loess time a valley of approximately the same course as the modern Ching Ho valley, there can be no doubt that the post-loess erosion, having removed the once continuous loess cover, has cut a juvenile valley deep into the rock ground.

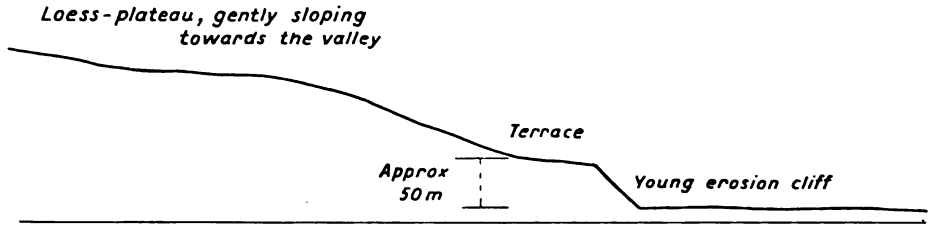


Fig. 22. North side of the Ching Ho, above Pinchow.

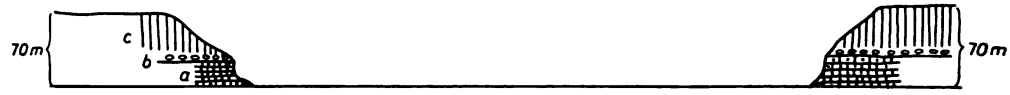


Fig. 23. Section across the Huang Ho at the ferry place Shang Pai Wan, 3 li above the village Ho Pao K'ou, Ching Yüan Hsien.

a. Red sandstone, nearly horizontal.
b. Conglomerate and gravel, few metres thick.
c. Loess.

The Huang Ho at Ching Yüan Hsien. During our march up through Shensi and Kansu in the early summer of 1923 we struck the Yellow River at Ching Yüan Hsien below the wild rock gorge through which the river flows between Lanchow and Ching Yüan Hsien. Here I noted at the ferry-place Shang Pai Wan, 3 li above village Ho Pao K'ou, the section shown in fig. 23. Its similarity to the Ching Ho section in fig. 21 is most striking. In both cases the rivers have cut down through the loess, the conglomerate and gravel as well as some tens of metres into the bedrock underlying the Pleistocene deposits. In this case the river is of much larger size than the Ching Ho; nevertheless the erosion channel cut by the latter river is much deeper, 190 metres, as compared with the 70 metres to which the Huang Ho has cut down the channel at Ching Yüan. But in both cases the process of erosion is in principle the same. In my field note book I have in this case given a detailed analysis proving that here the whole erosion must be post-loessic. Had the rock channel existed before the formation of the gravel on the top of the red sandstone, there should have been some gravel down

in the rock channel, but nowhere is this the case. Regularly over a large distance the gravel, partly consolidated into conglomerate, is to be seen between the sandstone and the loess with such regularity that there can be no doubt that the whole valley here was cut after the deposit of the loess was completed.

Some distance further up the river I sketched the southern bank of the river as seen in fig. 24. The river bank itself is exactly like fig. 23, but some distance from the river there rises a gentle slope, possibly the undulating sedimentation

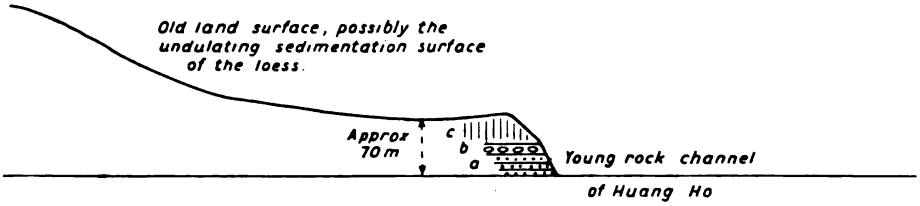


Fig. 24. South bank of the Huang Ho between Ching Yüan and Pei Wan.

a. Red sandstone.
b. Gravel-conglomerate.
c. Loess.

surface of the loess. This section also has its complete parallel in fig. 22 from the Ching Ho valley, and in both cases the loess slope may indicate a wide, gently sloping old river-valley obscured by the loess deposit. However this may be, the modern steep-walled valleys were undoubtedly cut by the rivers after the arid loess period had come to an end.

The Huang Ho gorge below Lanchow. When travelling home after a year and a half in Kansu, I floated down the river in the autumn of 1924 carrying all my collections upon two big rafts which are used in order to navigate the rapids below Lanchow. This method of travel gave me a rather exciting opportunity of studying the little known gorge through which the river flows here, with some interruptions in the way of open country, past Ching Yüan for a distance of about 200 km.

It may be worth while summarizing my notes from this memorable jorney.

The first ten kilometres below Lanchow the Huang Ho flows through the open Lanchow plain. To the south is the plain; the northern bank of the river is a steep cliff showing exactly the same section as seen in fig. 24: at the top is loess, underlaid by gravel and, below these Pleistocene deposits, a vertical cliff of the hard bedrock.

Then, at a distance of ten kilometres below Lanchow, the magnificent river suddenly makes a bend and rushes into the first gorge, »the small rapids», in Chinese *Hsiao Hsia*, (see Pl. XVII showing one of my rafts and the steering paddles of the other in the rapids).

After this first gorge follows 7 km. of open country and then the second gorge, »the big rapids», the *Ta Hsia*. A most striking feature of the gorge is shown in Plate XVIII: the mountains slope down to the river with steep sides but at a height of about 20 metres the slope turns into a vertical cliff bordering the river.

During the three days which it took us to traverse the gorges the second and third day were dominated by this feature: the steep mountain slopes rising to some few hundred metres, and bordered below along the river by a juvenile canyon with about 20 metres of vertical cliffs (fig. 25). To my mind the interpretation of these striking features is perfectly clear: the main rock valley some hundred metres deep was cut during the Fen Ho stage; while the 20-metre canyon framing the river is the product of post-loessic Pan Chiao erosion.

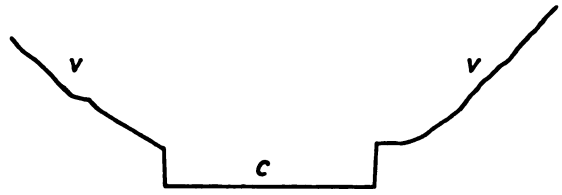


Fig. 25. Section through the Huang Ho gorge below Lanchow.

v. Steep sides of the Fen Ho stage valley.
c. 20 metres deep canyon of the Pan Chiao stage.

The Huang Ho above Lanchow. In the relatively open country above Lanchow there are very conspicuous terrace formations as shown in fig. 26. At some distance from the river there are high loess hills, entirely unexplored by me. They may represent the original sedimentation surface of the loess or a very high and old terrace comparable to the high terrace of the T'ao Valley (see below). Then there is a widely distributed 30-metre terrace, which I would interpret as the

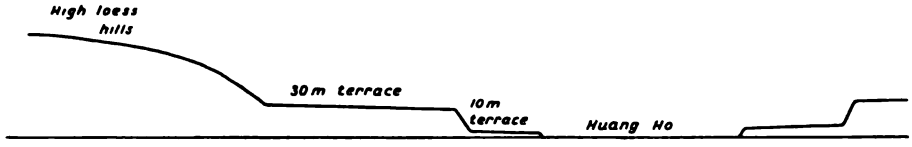


Fig. 26. Schematic section of the Huang Ho terraces above Lanchow.

Malan terrace of this area. Finally, close to the river there is a ten-metre terrace which is extensively irrigated, partly be irrigation channels drawn from places higher up the river and partly by means of very large »Persian wheels», which raise the water directly from the river to the terrace.

The Kueite basin. After a summer journey round Kokonor I arrived on the 14th of August at the edge of the Kueite basin. I knew this wonderful region from Loczy's excellent description, but the sight of it far surpassed my boldest ex-

pectations. Travelling over the rolling Tibetan grassland, I was suddenly arrested by a steep precipice, from the edge of which we looked down into wild canyon scenery. In a gorge a thousand metres deep the Huang Ho has cut its way down, partly in the multicoloured clays and sands of the Tertiary Kueite series, partly in »horst» hills of old crystalline rocks. The dark walls of the old horst rocks stood out splendidly against the brilliantly coloured Kueite beds. Deep down in this network of canyons I could perceive in one of the branch-valleys magnificent terraces bordering the streams.

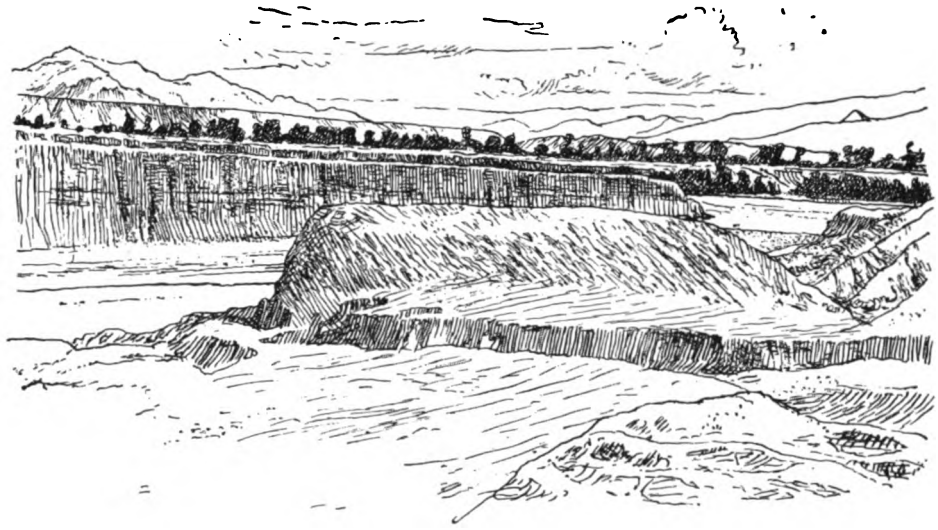


Fig. 27. The Kueite basin. Malan terraces at the village Lo Han T'ang.

During the weeks that followed we found at Lo Han T'ang, on one of the small tributaries to the Huang Ho, a rich site of the Yang Shao culture, and during the survey of this area I became very familiar with the terrace formations which entirely dominate these valleys. My observations are more fully recorded in my paper »Prehistoric sites of Northern China», which will soon appear in the Paleaontologia Sinica of the National Geological Survey of China. Here it will suffice to refer to figs. 27 and 28 showing two views of the Malan terraces of the Kueite basin. Fig. 27 gives a good impression of the fact that these terraces form the leading physiographic feature of these valleys. Their height is 20—30 metres, the lower half of which is cut into the soft Kueite sediments, the upper part consisting of gravels and loess. As seen from the picture, the terraces slope rather steeply and in complete conformity with the angle at which the modern valley-bottom slopes downriver.

As seen in fig. 28, these terraces also slope rather steeply away from the hill-slopes behind them. During the formation of the gravels abundant masses of waste rock were washed by torrents or slowly moved by solifluction. Thus originated this double slope of the terraces, downhill and downriver, which is so characteristic of the Malan terraces, not only in the Kueite basin but equally so in Hsi Kang, as we shall learn in a subsequent section of this volume.

Just close to the right of fig. 28, upon an isolated island of the terrace, lies the very rich and remarkable site Lo Han T'ang W. Here the face of the terrace towards the small river has a height of 31 metres, two thirds of which is cut into the Kueite clays and marls, but the upper one-third consists of gravel, and at the top of that 6 metres of loesslike material.

The Sining Ho valley. Sining Ho is together with its confluence the Tatung Ho, the largest tributary to the north of the Huang Ho on the Sino-Tibetan borderland.

The complex erosion phenomena and terraces of the Sining Ho valley are touched upon by Loczy in his work on the geological results of the Szechenyi Expedition in 1878—80.

Apart from some narrow rock-defilés (*Hsia* in Chinese), this valley is for considerable distances unusually broad with vast expanses of terraces of various heights. A typical case is figure 29 with three generations of terraces, the oldest and highest being in all probability the Malan-stage terrace. For some distance along the lower course of the Sining Ho, fig. 30 is typical of the scenery. On one side there is a high cliff of tilted Tertiary beds capped by loess, on the other there is a vast expanse, some three kilometres wide, of the young ten-metre terrace, and only beyond that the 30-metre Malan terrace with its usual section: bedrock, gravel and loess at the top.

The T'ao valley. This river is the main right hand tributary of the Huang Ho on the Sino-Tibetan borderland. Between two small places named Ho Pa Ssu and Hei T'ien Hsia it throws itself down from the Tibetan highlands upon an open tableland situated at an altitude of 2 000 metres above sea level. Fig. 31 shows a section of this rock canyon in which we can distinguish the same features that we found so dominant in the big Huang Ho canyon below Lanchow: in the upper part a steep sloping rock valley of beginning maturity and below, some tens of metres in height, a juvenile canyon with vertical cliffs framing the river.

Figure 32 gives the surroundings of the T'ao river as it has entered the Tertiary tableland. At an altitude of 400 metres above the river-bed of the T'ao Ho the rounded and loess-capped hilltops of this tableland indicate an ancient dissected peneplain.

The details of the river-valley are represented on a somewhat larger scale in fig. 33. At a considerable height and at some distance from the river is a high terrace, which was not explored by me. At a height of 40—50 metres above the

Fig. 28. The Kueite basin. The Malan terrace below the prehistoric site Lo Han T'ang W.

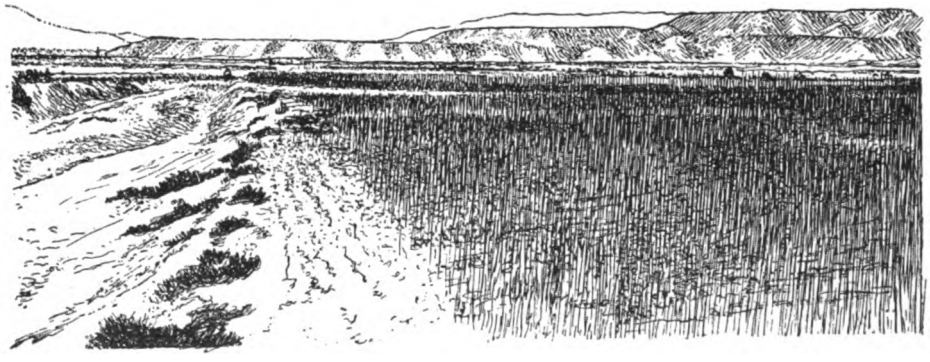


Fig. 29. Terraces of the Sining Ho.

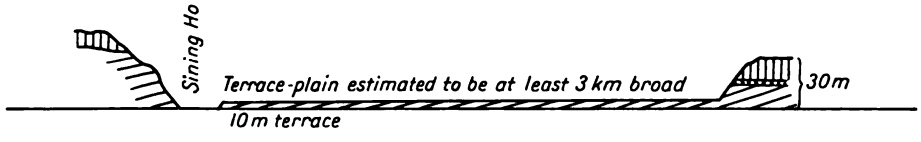


Fig. 30. Schematic section of the Sining Ho valley.

river plain we find the escarpment of the almost continuous Malan terrace, which is the bearer of the very rich prehistoric sites that have made the T'ao valley famous. The structure of the Malan terrace is the same as that we have found in so many instances in other valleys of Kansu: at the bottom bedrock, and above these Tertiary beds the gravel bed, which is as usual capped by the loess.

Fig. 31. The T'ao Ho canyon at Hei T'ien Hsia.

Plate XIX shows the broad and open river-valley both downriver and upriver as seen from the Malan terrace above Hsien Tien village. In both views we can follow for long distances the continuous escarpment of the Malan terrace. Figure XX B shows in the background on the distant side of the river at the level H the high, unexplored plateau, and at M—M the continuous escarpment of the Malan terrace.

The upper figure of the same Plate XX shows in the foreground a low terrace consisting of re-deposited loess and gravel. The high hills in the background belong to the here deeply dissected Malan terrace, which is 60—70 metres high. Round the lone tree at the top of the central hill is the rich Hui Tsui Bronze Age site (fig. 34).

CORRELATION OF THE OBSERVATIONS IN NORTHERN CHINA

The earliest physiographic feature described in this paper is the strongly dissected T'ang Hsien land-surface of the Chai T'ang area.

In the Tertiary surroundings of the T'ao river of Kansu we have met a level of high loess-capped hill-tops which seem to indicate what I have tentatively named a dissected peneplain. It would be tempting to correlate this feature with the T'ang Hsien land-surface. But I am under the impression that the Tertiary series building up the surroundings of the T'ao valley is too young to allow of such a correlation. This Tertiary series is, moreover, so slightly tilted that the old dissected surface indicated by these hilltops may be not a former peneplain but rather the sedimentation surface of the Tertiary formation.

The next physiographic stage to be considered here is the Fen Ho period of deep vertical erosion, the cutting of the large river-gorges such as those of the

Hun Ho, the Fen Ho, the Huang Ho and the T'ao Ho. It should at once be noted that there is also a much later stage of vertical erosion, the Pan Chiao stage, which we can date as post-loessic but pre-Yang Shao, as in Kansu the Yang Shao sites are built upon the ready-made escarpment which the Pan Chiao erosion carved into the Malan valley plain.

The main problem in the interpretation of the Pleistocene physiographic history of Northern China is the question: How far are the present big gorges of the North China rivers the product of the Fen Ho or of the Pan Chiao erosive stages.

We have pointed out how all the big gorges examined by me, the Hun Ho above Ching Pai K'ou, the Huang Ho below Lanchow and the T'ao Ho at Hei T'ien Hsia, show the same marked feature: a steeply sloping rock valley of some maturity and below that a juvenile canyon with vertical rock walls about 20 metres high framing the roaring river.

This canyon might possibly be quite recent and its formation still going on thanks to the lateral cutting of the river. But the observations in Shensi and Kansu outside the gorges, in the Ching Ho below Pinchow, in the Huang Ho at Ching Yüan Hsien and in the T'ao valley at Hsin Tien point to a quite different conclusion. Even granted that some features of Fen Ho age erosion may be hidden under the loess cover, which is the dominating factor of the Shansi-Kansu plain, there remains, as we have seen more in detail in the local descriptions, the fact that in the case of the Ching Ho and Ching Yüan Hsien sections there is clear evidence of a Pan Chiao erosion, which has cut down not only through the continuous loess cover and the underlying gravel bed but also much deeper into the bedrock of Palaeozoic (?) sediments to a depth of 30—50 metres. In these places the post-loessic vertical erosion is proved beyond all doubt.

If we start from such a definite conclusion it seems very likely that the vertical rock canyons, which are something like 20 metres in height in the gorges, are also the product of the same Pan Chiao erosion that cut the Ching Ho and Ching Yüan canyons in the open plain. In other words, we can hardly escape the assumption that the big gorges have been deepened and revived during the Pan Chiao stage. If we now try to summarize our actual observations on the Pan Chiao vertical erosion, we arrive at the following body of recorded facts:

Chai T'ang. Removing to a depth of about 40 metres nearly all the Malan gravels which certainly once filled the main valley of Chai T'ang, and partially removing these gravels also from the side valleys, such as the Ma Lan, the Ho Tsun and the Ching Lung Chien valleys, where only parts of the once continuous Malan valley-plain is preserved as central lobes or fringes along the valley sides.

Pan Chiao. Cutting narrow canyons 20 metres deep into the hard bedrock.

Hun Ho. In certain sections cutting rock canyons some tens of metres deep, in others the dissecting of the Malan gravel terraces. Special interest should be given to the conditions at Kuan Ting, where the Hun Ho runs from the plain

into a juvenile canyon, the depth of which seems to correspond approximately to the height of the »barranca» of tilted Sanmen beds on the east side of the river just above its entrance into the gorge.

Shensi. Ching Ho below Pinchow. Cutting a valley right through the loess, the gravel and the underlying bedrock, which is eroded to a depth of about 50 metres.

Kansu. The Huang Ho at Ching Yüan. Cutting a valley 70 metres in depth through the loess, the gravel and the bedrock.

The Huang Ho gorge below Lanchow. Deepening the gorge cut during the Fen Ho stage with a vertical canyon, 20 metres in depth.

The Huang Ho in the Kueite basin. Dissecting the Malan gravels down to a depth of 30 metres.

The T'ao Ho, Hei T'ien Hsia. Deepening the Fen Ho gorge into a narrow vertical canyon.

The T'ao Ho at Hsien Tien and Hui Tsui. Removing a large part of the Malan gravels and shaping the remainder into a continuous terrace 40—70 metres high.

The accumulated Fen Ho and Pan Chiao erosion form only one aspect of the physiographic history of the North China valleys. Between these periods of erosion there was a stage of accumulation when gravels interbedded with loess-like material filled the valleys to a thickness of several tens of metres.

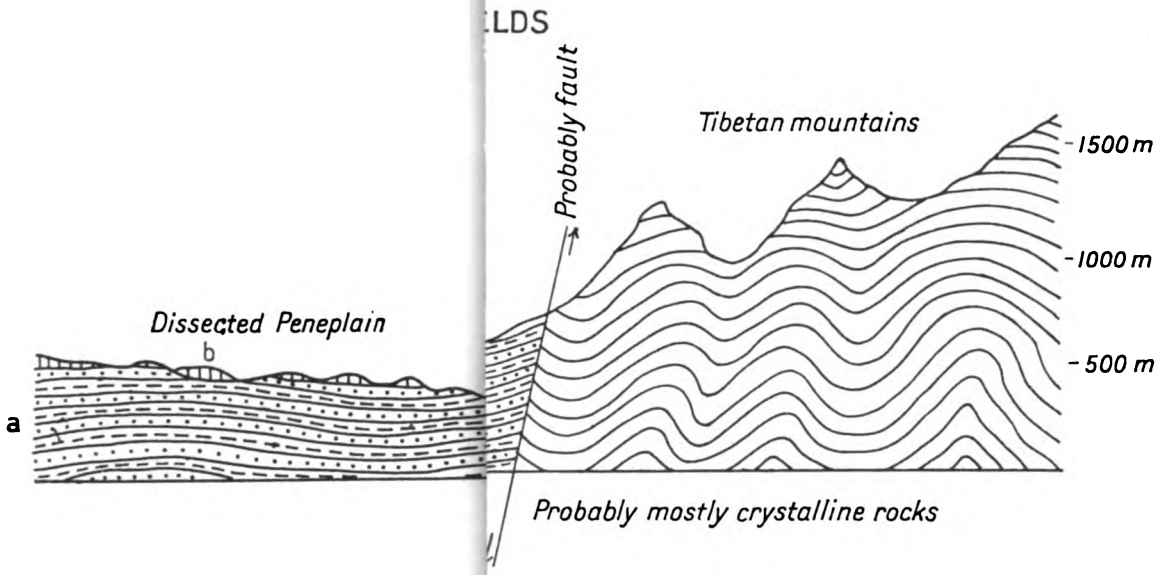
There are indications of very high terraces, as for instance in the T'ao valley, see fig. 32. This much-dissected terrace, which is more than 100 metres above the river, was never examined by me.

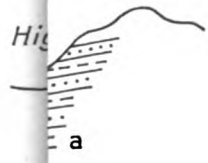
On the other hand, there are terraces very low down, as for instance the 10-metre terrace of the Huang Ho above Lanchow and of the Sining Ho (fig. 26, 30).

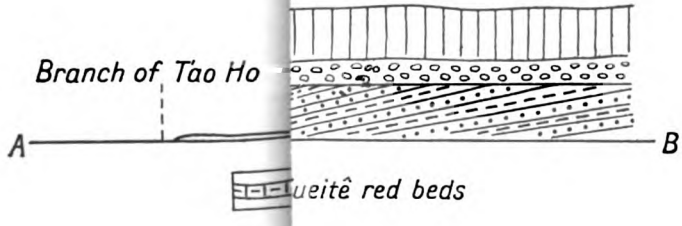
But in all these valleys there is one feature overshadowing all others, the terrace-generation named by me the Malan terraces. All other terraces, both high and low, are insignificant and sporadic when compared with those of the Malan stage.

Take for instance the Chai T'ang basin. Side-valleys such as Ma Lan, Ho Tsun, and Ching Lung Hsien are entirely dominated by the Malan terraces. So is also the T'ao Ho valley, where the Malan escarpments can be followed continuously for tens of kilometres. When, in the following section of this volume, we turn to Hsi Kang, we shall learn how the Malan terraces more than anywhere else dominate those distant valleys.

In type the Malan terraces are everywhere identically the same: well preserved remnants of a once continuous valley-plain which has been dissected by the Pan Chiao erosion. In altitude the Malan escarpments are variable even within the same valley. Occasionally they may be as low as 20 metres. In Chai T'ang they are about 35 metres and in the T'ao valley 40—70 metres. The altitude of these escarpments is due primarily to the amount of sediments deposited in the valley during the period when the Malan valley-plain was formed, and then upon the depth to which the vertical erosion in each case cut down during the Pan Chiao stage.







We have here dealt with four consecutive physiographic stages of the North China valleys: the Fen Ho stage of very deep vertical erosion, a stage so distant in time that the river valleys cut during that time had already developed features of maturity. Then follows the Sanmen stage with the »ponding» of the valleys, and subsequently the Malan stage, when the valleys were partially filled with voluminous accumulations of gravels interbedded with sheets of loess. The climax of this development seems to have been the deposit of valley covers and local hills of pure loess. When this cycle was completed, the valley floors were filled to a thickness of several tens of metres with a sheet of local gravels with interbedded loess, the whole forming the Malan deposits.

Long after these happenings were completed, there set in a new cycle of vertical erosion, the Pan Chiao stage, which cut down 30—60 metres deep in some valleys in the Malan gravels, but in other sections of the rivers not only into the Pleistocene gravels and loess, but also into the solid bedrock, forming canyons which stand quite intact with vertical sides.

Here is a further question to be answered: what were the forces that twice produced periods of vivid vertical erosion, and between these stages of river-cutting a stage marked by the deposit of gravels and loess?

One alternative is geotectonic movements causing an increase in or a retardation of the erosive power of the rivers. If the base level of the rivers is lowered, and consequently their grade is steepened, a renewal of the vertical erosion will be the result. On the other hand, if through warping the grade is lessened or finally reversed, then there will develop a »ponding» of sections of the valleys as described by Barbour to account for the lacustrine deposits of the Sanmen stage. I take it for granted that warping and other types of dislocations within the earth's crust have played some part in producing some of the phenomena here described. But these happenings are too general and widely distributed to be referred only to geotectonic dislocations, which should affect the river valleys locally and differently in different sections of a valley.

For these reasons I feel convinced that climatic changes have been the main and regionally active factor producing these effects. The formation of the eolian loess is a distinctly climatic process caused by a progressive arid climate. But the gravel fillings in the valleys may also be referred to this period of arid conditions. A steppe or desert climate is characterized not only by eolian deposits. Rain is scarce, but comes, after long intervals, as violent cloudbursts apt to wash down the waste from the nearby valley-sides, allthough of too short duration to be able to carry the gravels more than a short distance down the valley.

On the other hand, a rainy climate will cause a continuous flow down throughout the total length of the river, and at high water the current will become so strong that all sediment, except the heavy boulders, will be swept away, and vertical cutting will begin to deepen the valley. Consequently the two erosion periods are to be looked upon as periods of abundant rain, whereas an intervening period

of dessication caused first ponding, then the washing down of abundant gravels, and finally the depositing of pure eolian loess.

This way of explaining the three stages here described raises another issue: during the erosion periods the rivers in Chai T'ang, in the T'ao Ho valley etc. must have flown much deeper than the modern rivers which meander over gravels, sand and silt of unknown but certainly considerable thickness. When the arid Malan climate began to develop the Chai T'ang main valley and the T'ao valley were considerably deeper than they are to-day.

Similarly, it is quite likely that in certain regions the Pan Chiao erosion reached to a greater depth than we can calculate to-day. It seems as if the climate of to-day is not the pluvial climate of the maximal Pan Chiao erosion. Since that time the gravels have again begun to rise upon the valley bottoms while the climate is undergoing that change into a state of semiaridity which characterizes Northern China of to-day.

GLACIOLOGICAL AND ARCHAEOLOGICAL RESEARCH IN HSI KANG.

ORIGIN AND COMPOSITION OF THE HSI KANG EXPEDITION.

In the summer of 1937 I had an opportunity of studying the archaeology and certain features of the geological history of that part of Hsi Kang which is located NW of Tatsienlu (Kanting). Some of the observations on the former glaciation, the Malan terraces and the presentday erosion were also derived from the journey between Yachow (Yaan) and Tatsienlu.

There were three considerations that brought me to Szechuan and beyond. First of all, in view of my extensive archaeological fieldwork in Kansu and Chinghai in 1923—24 it seemed important to find out whether late Neolithic sites similar to those of these northern provinces occur also in Szechuan and Hsi Kang. Furthermore, the reported finds by J. Houston Edgar and others of supposed Palaeolithic implements indicating the occurrence in Hsi Kang of certain sites, parallels to which I was never able to discover in Kansu, made a close examination of the suggested Palaeolithic of Hsi Kang highly desirable. Last but not least, the existence in Chengtu, the capital of Szechuan, of an archaeological museum, the Museum of Archaeology, Art and Ethnology of the West China Union University with its curator Dr. D. G. Graham, himself an enthusiastic worker on the archaeology of these regions, formed a powerful attraction for a student with my interests.

Accompanied by my assistant Miss V. C. Dorf and my veteran servant from the Kansu campaign, Chuang, I arrived in Chengtu on the 1st June and was most hospitably received by Dr. Graham.

In the negotiations that followed with the principals of the two Chengtu Universities, The National University of Szechuan and the West China Union University, it was agreed to organize a joint expedition with representatives of the two Universities under my leadership. The National University of Szechuan was represented in our field staff by Dr. Chow Hsou Ho, lecturer in geology at the said University. As it was agreed that all the collections made were to become the property of this University, Dr. Chow was in charge of registrering and taking care of this scientific material. Furthermore he acted as our intermediary in the negotiations with local officials, a duty which he executed with noticeable tact and skill. The West China Union University was represented by Dr. Graham, who was specially in charge of all practical matters connected with the caravan. I take this occasion to convey to Dr. Graham my sincere thanks for the valuable assistance thus rendered.

Very fortunately for us there arrived in Chengtu in the early stage of our negotiations Dr. Fu Ssu-nien, Director of the Department of History and Philology in the Academia Sinica, Nanking, and I owe him a special debt of thanks for his invaluable help in bringing the negotiations to a happy issue. Dr. Fu further showed his interest in our enterprise by sending with us one of his young associates, Dr. Ch'i Yien Pei who most ably directed the excavation of the Neolithic sites of Tao Fu Hsien.

I also wish to express my thanks to my personal assistant Miss Vivian C. Dorf, who with remarkable skill and resourcefulness acted as »house»-keeper, accountant, artist and photographer of the party.

We left Chengtu on the 25th June and arrived in Tatsienlu on the 5th July. Here our Hsi Kang caravan, consisting of horses for ourselves and yak-oxen for our outfit, was duly organized, and the 10th July we started for the country above Tatsienlu. We first travelled south and west to Jedo, where we disposed of two of Edgar's »sites» and found the first ground-moraine with profusedly striated boulders. (A terminal moraine had already been discovered on the 4th July near Lu Ting Chiao below Tatsienlu.) Our route was now laid due west until we reached Ying Kuan Chai. Near this place, at Agato, we met the first typical Malan-terrace as well as a considerable loess deposit. Upon the Agato terrace we found at one spot some few small sherds of prehistoric pottery. We now travelled north to T'aining and from there NW to Tao Fu Hsien, which became the centre of our archaeological research. Following the remarkable Tao Fu rift valley, we made an excursion to the placer gold field of Chiang Chun Chiao, and two members of the party went as far as Sharatong.

The rich archaeological finds in Tao Fu Hsien made it desirable to extend the work further west to the valley of Ya Lung Chiang. But the disquieting news about the war situation in northern China forced us to curtail the fieldwork and return to Tatsienlu. This time we went from Taining up the Gachala pass, where we discovered a ground moraine of special significance for solving the problem as to the nature of the old glaciation. Later, on the return journey, we had a magnificent opportunity of studying the glaciated mountain Minya Zara (5 900 metres) and its old local moraines. Further glaciological observations were collected in the valley leading from Minya Zara down to Tatsienlu.

From a base of only 647 m at Yachow we climbed during the first stage of our journey to 2 569 m at Tatsienlu. But on this route we had on two occasions to climb mountain passes reaching nearly 3 000 m (Ta Hsiang Ling, 2 833 m) and to descend to only thousand meters between the passes. This gives some idea of the strongly broken topography of this area, with narrow ridges crowned by sharp peaks and between them unusually steep and narrow valleys.

Above Tatsienlu we worked mostly at altitudes between 3 000 and 4 000 m, but we passed close to a glacier-clad mountain Minya Zara (5 900 m). The highest of all the mountains in this region is Minya Gongkar, (7 700 m).

EARLIER OBSERVATIONS ON FORMER GLACIATION.

The idea of an extensive Pleistocene glaciation on the Sino-Tibetan borderland is not new. Loczy, the geologist of the Széchenyi expedition travelling in these regions in 1877—80 was of the opinion that he had met traces of a considerable former glaciation.

Loczy's observations on the glaciation of Hsi Kang are most noticeable in the light of the opinion of later visitors, specially the interpretation given by Arnold Heim. For this reason I consider it advisable to quote here in full all Loczy's statements on a former glaciation. All the following entries are taken from the first volume of the official publication on the expedition under the leadership of of Count Béla Széchenyi: »Die wissenschaftlichen Ergebnisse der Reise des Grafen Béla Széchenyi in Ostasien 1877—1880.»

The first entry (page 694) refers to the region of Lu Ting Chiao on the way from Yachow to Tatsienly. Exactly the same locality is here described on page 58 according to my observations. In order to facilitate the comparison of my observations with those of Loczy it should be noted that that author spells Lou-ting-kjao (Lu-ting-kjao) instead of our Lu Ting Chiao. The river that flows along this valley is called by Loczy Lu-ho instead of Ta-tu-ho, as in the atlas of the Geological Survey.

Here follows the description given by Loczy:

Page 694:

»Circa 13 Kmtr. weit erblicken wir zu beiden Seiten des Lu-ho-Thales hoch über dem Flusspiegel gewaltige Trümmeranhäufungen, die sich in der Richtung des Wasserlaufes thalabwärts ziehen. Diese Steinwälle bestehen aus unregelmässig eckigen und abgerollten Blöcken und sind dieselben von dem fest anstehenden Felsengesteine durch eine grabenartige Vertiefung getrennt. Diese Steinwälle sind um so beachtenswerther, als sie durch ihre beiderseitig hufartigen Einkrümmungen den Übergang der Seitenmoräne zur einstigen Endmoräne andeuten. Schon früher habe ich unterhalb Lou-ting-kjao an der rechten Thalseite des Lu-ho solche Trümmeranhäufungen beobachtet, woselbst ich in der Nähe zweier sich vereinigender Wildbäche ganz ähnliche Wälle sah.

Baber hatte etwas unterhalb jenes Punktes, wo der Se-tschuen-er Weg das Lu-ho-Thal erreicht ebenfalls ähnliche, aus eckigen Riesenblöcken bestehende Trümmerwälle beobachtet. Zwischen den Ortschaften Mo-si-mien und Lama-su fliessen dicht nebeneinander in N-S-licher Richtung zwei Flüsschen, um dann miteinander vereinigt sich in den Lu-ho zu ergiessen. Zwischen denselben erhebt sich ein dammartiger Hügel. Mo-si-mien liegt am Ende dieses Dammes, welcher in das enge Thal herabreicht, und zu beiden Seiten von undurchwatbaren Wildbächen umrauscht wird. Es gleicht dieses Dammende dem Bugsprit eines Riesenschiffes, das sich in die vor ihm vereinigenden Wässer hinabsenken will. Die obere Fläche des Dammes ist flach und ist das Dorf am Rande derselben gelegen.

Dieser Gesteinswall ist länger als 3 engl. Meilen, seine Breite circa 1/4 Meile und seine Höhe etwas mehr als 250 Fuss.[1]

Baber hielt diesen Damm für eine Moräne. Auch auf mich machten diese Erscheinungen den Eindruck, als ob die Gletscher des Gebirges bei Ta-tsien-lu in der jüngst vergangenen Zeit tiefer herabreichten als jetzt.

In der Nähe von Lou-ting-kjao liegt der Rücken der Moränen 1 500 Mtr., bei Lama-su 1 700 Mtr. (5 590 Fuss) hoch über dem Spiegel des Meeres.

Der Gesteinsschutt, welcher die Thalgehänge des Lu-ho bedeckt, liefert zugleich einen Beweis für die Erosion des Thales.

In grosser Höhe, 700—800 Mtr. über dem heutigen Thalbecken, sind die unter 45° geböschten Bergwände rund abgeglättet und selbst in einer Höhe von 200 Mtr. über dem Flusse finden wir noch grobe Geschiebe.

Doch ist auch jene Möglichkeit nicht ausgeschlossen, dass die obenerwähnten Schuttdämme mit ihren grossen Gesteinsblöcken in Folge der raschen Eintiefung des Thales durch Bergstürze verursacht worden sind.»

The »Trümmeranhäufungen» mentioned by Loczy from 13 km above Lu Ting Chiao are evidently the terminal region noticed by me about 15 li above this place and described here page 58.

Baber's observations apparently refer to the interesting area mapped by Heim as the type locality of the Mosimien stage of a local former glaciation. What Loczy mentions as »ein dammartiger Hügel» is evidently the beautiful Malan terrace so graphically depicted by Heim (Minya Gongkar, page 95). The whole description: »es gleicht dieses Dammende dem Bugsprit eines Riesenschiffes, das sich in die vor ihm vereinigenden Wässer hinabsenken will» forms a word-picture of this type of Malan terraces, just as graphical as the masterly sketch made by Heim.

On this page 694 of Loczy's volume are combined under one heading physiographic features of a widely different kind: the terminal moraines of Lu Ting Chiao and the Malan terrace of Mosimien. In addition, Loczy's final remark that the boulder beds described by him may have been formed by some kind of landslide, has evidently influenced Heim in discarding those observations by Loczy in which he describes actual old moraines.

The next notes on ancient glacial deposits given by Loczy we find on page 699. They refer to observations made near the hunting castle Yu-lin-kon belonging to a Tibetan chieftain and situated SSE from Tatsienlu:

Page 699. »Zwischen Yu-lin-kon und dem Passe reichen von O Moränen herab, und wird der Weg am rechten Thalgehänge von einer mächtigen Seitenmoräne begleitet, die von der felsigen Thalwand durch eine parallele Vertiefung getrennt wird, in welcher sich kleine runde Teiche befinden. Die Seitenmoräne besteht aus grossen eckigen Blöcken und einem sehr gemischten Gesteinsmateriale. Die von mir aufgezeichneten und gesammelten Gesteine waren folgende: Quarz-

[1] C. Baber. Supplementary Papers. Roy. Geogr. Soc. Vol. I, Part. I, pag. 48—49.

diorit, Amphibolgranit, Gneissgranit, porphyrischer Granit, Diabas, porphyrischer Diabas mit grossen, sternenförmig angeordneten Feldspathgruppen und schliesslich echter Gneiss. Die Seitenmoräne ist noch vollkommen scharf und kahl, doch reicht ihr unteres Ende bereits in den Wald herab und liegt dasselbe laut meinen Aneroidablesungen circa 3 570 Mtr. über dem Spiegel des Meeres. Vom Sattel aus kletterten wir in O-licher Richtung bis an das untere Ende der jetzigen Gletscher hinauf, wo sich die untere Grenze des Gletschereises in einer Höhe von 4 500 Mtr. befindet.

Gegenwärtig hängen von den Ta-tsien-lu-er Gebirgen, diesen ersten Bastionen des tibetanischen Hochlandes gegen China hin, blos noch kurze Gletscher zweiten Ranges herab.

Diese Gletscher vereinigen sich in dem oberhalb des *Ja-tschiu*-Passes gelegenen Circusthale, welches einst die obere Firnmulde jenes grossen Gletschers gewesen ist, der sich gegen den Sattel zu wendend noch in jüngst vergangener Zeit in der Richtung gegen Ta-tsien-lu herabwanderte und dabei die erwähnte mächtige, rechte Seitenmoräne zurückliess, deren unteres Ende wir beim Jagdschlosse Yu-lin-kon angetroffen haben. Nach diesen Beobachtungen zweifle ich nicht im Mindesten daran, dass jene riesigen Gesteinstrümmer, welche die Sohle des Ta-tsien-lu-Thales bedecken und von welchem sich ein Exemplar auch im Hofe unseres Gasthauses befand, nicht wirkliche Wanderblöcke wären.

Ebenso kann ich nun auch die am Lu-ho beobachteten Schutthaufen mit viel grösserer Sicherheit als die Spuren der einstigen osttibetanischen Gletscher betrachten. Um die Altersverschiedenheit zwischen den unteren und den oberen Gletscherspuren festzustellen, besitzen wir gar keine Anhaltspunkte. Ich kann blos nur bemerken, dass die oberen verlassenen Moränen kaum viel älter als die heutigen Wälder sein dürften, da sie noch vollständig kahl und jedes Baumwuchses bar sind, dass sie ferner bei einer absoluten Meereshöhe von 3 000—3 300 Mtr, die charakteristischen scharfen Formen der Moränen noch völlig intact erhalten haben. Die unteren dagegen, die um 2 000 Mtr. tiefer gelegen sind (wenn sie sich wirklich als echte Moränen erweisen sollten), stammen aus einer dem gegenwärtigen Waldwuchse vorangegangenen solchen Zeit, zu welcher die Flussbette noch um 500—700 Mtr. höher gelegen waren als heute».

I was not able to visit the area here described, but Loczy's words foreshadow the opinion formed by me that we have in addition to the local Mosimien moraines of very late Pleistocene age traces of a much older glaciation covering regionally the larger parts of this area. But the descriptions given by Loczy are again rather non-commital: »wenn sie sich wirchlich als echte Moränen erweisen sollten».

Loczy's next observation refers to Tsche-to-shan (Che To Shan in the map of the Geological Survey), a mountain situated 18 km west of Tatsienlu:

Page 700. »Durch das Dorf Tsche-to oder vielmehr durch die aus einigen Häusern bestehende Pferdewechselstation wird diese 3 300 Mtr absolut hohe Thalstufe bezeichnet. Es vereinigen sich daselbst zwei grosse Seitenthäler, deren

eines, das Tar-kjo-Thal, von SW her von den Gletschern des Kunkagebirges sich herabzieht. In dem anderen grossen Thal steigt der nach Lassa führende Weg in WNW-licher Richtung an, wendet sich aber von dem 4 499 Mtr. hohen Dje-la-Passe in gerader Richtung nach N, und zwar an dem Punkte, wo von O her ein von nicht alten, noch scharfen Moränen erfülltes Seitenthal des Tsche-to-shan in das Hauptthal einmündet, dessen steilere, südwestliche Gehänge von mächtigen Moränen bedeckt werden.»

Sid. 701. »Die vor dem *Dje-la*-Pass befindlichen Moränen bestehen aus vom Tsche-to-shan herabtransportirten Gneissgranit, Augengneiss, Dioritgranit und grobkörnigem Granit und befinden sich in den granitischen Gesteinen ebenfalls feinkörnige Dioriteinschlüsse.

Im Hintergrunde des Tsche-to-Thales bilden die Granit- und Gneissfelsen einen halbkreisförmigen Thalkessel, aus welchem der einstige grösste Gletscher des Tsche-to-shan vor nicht allzulanger Zeit bis zur Ortschaft Tsche-to herabreichte, wie dies die noch vorhandenen frischen Moränen unwiderleglich beweisen. Gegenwärtig dürfte sich jedoch unter diesen Schutthalden schwerlich noch Gletschereis befinden.»

Ten km SSW of Che-to-shan I found at Zurahaki a ground-moraine bed, at least 8 m in thickness and containing innumerable rounded and striated boulders, the glacial nature of which can in no way be doubted (see p. 55).

The following note by Loczy refers to Dson-go, a village further west of Tatsienlu:

Page 703. »Es erinnert diese Gegend sehr an die Lösshügel von Lantschou-fu. Die hiesigen Hügel werden übrigens von einer dünnen Humusschicht bedeckt, so dass Wiesengraswuchs ihr nacktes Gestein verbirgt. Zu beiden Seiten des Thales befindet sich eine Art von Terrasse, die aus Gesteinsblöcken und Schotter besteht und ohne Zweifel einstigen Gletschern ihren Ursprung verdankt; auch finden wir unter demselben gekritzte Geschiebe. Trotzdem ist es evident, dass die Gletscher gegen W nicht so weit herabreichten, wie in den tiefen Thälern des Ta-tsien-lu. Bei Ti-zu sind im Hintergrunde der Seitengräben noch die Querdämme von Endmoränen sichtbar, hinter welchen sich je ein kleiner Teich ansammelte; bei *Agnian-pa* und *Dson-go* dagegen sind an den Schotterterrassen die charakteristischen Moränenformen nicht mehr erkennbar. Die Terrassen werden hier von einem gelben lössähnlichen Lehm bedeckt.»

At Gara-la, west of Litang, Loczy made the following observations:

Page 709. »Unser Weg führte in einem vom Gara-la nordöstlich sich herabziehenden Thale zwischen Gletscherschutt und Moränen aufwärts. Dieses geräumige Thal wird zu beiden Seiten von Schuttwällen eingesäumt. Es sind dies kahle, jeder Vegetation noch bare Moränen, zwischen deren Gesteinstrümmern wir am häufigsten Amphibolgranitblöcke, spärlicher dagegen Sandstein und kalkige Thonschiefertrümmer antreffen.

Unser erstes von Le-tung westlich gelegenes Nachtquartier lag oberhalb der Theilung des Thales in der Nähe der Grenze zwischen Sandstein und Granit.

Die hier im Umkreise sichtbaren Moränen sind vollkommen intact, und ungefähr 1 Kmtr. oberhalb der Herberge hebt sich zwischen den Seitenmoränen eine hufeisenförmige Stirnmoräne scharf ab, die von dem Gebirgsbache mitten durchschnitten wird (Fig. 131). Weiter hinauf zu ist das Thal 700—800 Mtr. breit und besitzt eine vollkommen ebene Sohle, eine Erscheinung, welche aus den Alpen an den oberen Enden der Thäler die erst unlängst von Gletschern verlassen worden sind, sattsam bekannt ist».

»Bis zur Sattelhöhe begleiteten uns verhältnissmässig sanfte Gehänge, vom Rücken an erheben sich jedoch plötzlich 1 000—1 200 Mtr. hohe, scharfe, pyramidenförmige Gipfel, zu deren beiden Seiten sich halbkreisartige Kesselthäler befinden. Diese, beiläufig 4 800 Mtr. hoch gelegenen Kessel hatten mit ihren Firnmassen die einstigen Gletscher gespeist. Gegenwärtig liegt nicht einmal Schnee mehr in diesen Thälern, da selbst jene Schneemassen, die als Lawinen von den umliegenden Granitgipfeln herabgelangen, in diesen einstigen Firnkesseln im Laufe des Sommers gar bald schmelzen. Nirgends hatte ich besser Gelegenheit, die Spuren einer jüngstvergangenen Gletscherzeit so auffallend zu beobachten, als gerade an den Abhängen des Gara-la.»

On Lakando station between Litang and Batang Loczy makes this note:

Page 713. »Beiderseits der Thalweitung liegen hohe Trümmerhaufen, die den Seitenmoränen des einstigen mächtigen Gletschers entsprechen; dieselben reichen bis zu dem unterhalb Ranung befindlichen Thalpass. Oberhalb Ranung ist auf der Thalebene noch eine jüngere Stirnmoräne sichtbar. Von hier führt der Weg bis zur nächsten Station *Lakan-do* fortwährend über Moränen und Gletscherschutt, und auch auf den Gehängen und Nebenrücken liegt eine Unmasse von Gesteinstrümmern. Die Gussregen schufen in diesen Schuttmassen grosse Wasserrisse und liessen in dem mit grossen Trümmern untermischten eckigen Schotter Erdpyramiden entstehen».

»Vom Jela-Pass stiegen wir in westlicher Richtung über Moränenschutt gegen die Station *Lakando* in ein geräumiges Thal herab.

Lakando liegt auf der 500—600 Schritte breiten Thalsohle eines Nebenzuflusses des Ra-dschu; der Weg setzt über einen mächtigen Gebirgsbach hinüber unweit von dessen Einmündung in den erwähnten Nebenfluss und führt das klare Wasser dieses Gebirgsbaches schneeweissen Granitsand mit sich. Die Passirung dieses Baches wird durch eine Brücke vermittelt, unterhalb welcher am rechten Bachufer Kalktuff und eine Salzausblühung sichtbar werden, als die Absätze einer heissen Quelle. Am linken Ufer unweit der Brücke ist an der Thalsohle eine mächtige Endmoräne sichtbar, die mit der linksseitigen Seitenmoräne verschmilzt.»

Sid. 717. »Vom Anblicke dieses Thales, sowie von den dasselbe umgebenden Schneegebirgen gibt Fig. 133 einigermassen einen Begriff; zur Rechten sahen wir die Lawinen des *Gambu-Kunka*-Gletschers, zur Linken die sich zurückziehenden hängenden Gletscher des niedrigeren Genje-Gebirges mit ihren regelmässigen

Moränen; im Vordergrunde dagegen schlängelt sich das silberne Band des Rati-Flüsschens durch die grüne Flur. Die Thalsohle ist vollkommen eben, besitzt einen geringen Fall und erinnerte mich lebhaft an den zwischen dem *Grimsel-Hospiz* und dem *Unter-Aargletscher* gelegenen Thalabschnitt. Oberhalb Rati brach der Fluss durch eine aus mehreren unregelmässigen Schuttwällen bestehende Stirnmoräne durch, die ungefähr 12—15 Mtr. hoch, zu beiden Seiten hufeisenförmig zurückgebogen und mit den zu beiden Seiten befindlichen, scharf ausgeprägten Seitenmoränen verschmolzen ist. Eine zweite Stirnmoräne befindet sich weit oben im Hintergrunde des Thales an der Vereinigung mehrerer Seitenthäler, während die dritte, die unterste Stirnmoräne, die Station Rati auf ihrem Rücken trägt. Die zwischenliegenden Thalflächen werden von mächtigen Wanderblöcken bedeckt, von denen der eine im Vereine mit drei daneben aufgepflanzten Fahnen als Grabstein für einen in den Bach versenkten Leichnam diente; das buddhistische Gebet in tibetanischer Sprache: »Om-mani-pudmi-hum» war mit lapidarischer Schrift frisch in den Stein eingemeisselt.

Die Thalsohle, sowie die Moränen sind bereits mit Graswuchs bedeckt und boten den zahmen Yak-Heerden eine saftige Weide.

Diese Gegend war auch von landschaftlichem Standpunkte unbeschreiblich erhaben, für den Geologen aber, sowie den alpinistischen Touristen geradezu ein Eldorado. Trotz 4 000 Mtr. absoluter Höhe befanden sich hier ständige Wohnhütten und führt der stark betretene Weg um den Fuss des Gebirges herum, auf dem man zu Pferde eine Höhe von 5 500 Mtr. erreichen kann. Zu dem Versuche, 7 000 Mtr. hohe isolirte Spitzen zu erklettern, um in reiner, durchsichtigster Herbstatmosphäre eine der weitesten Aussichten der Erde zu geniessen, dürfte sich kaum ein anderer Punkt so sehr eignen, als eben Rati.

Wir aber hatten keine Zeit und eilten ohne Rast den nächsten Tag auf dem nach Lassa führenden Wege weiter. Wir schritten an der westlichen rechten Seite des Thales auf der daselbst befindlichen Seitenmoräne aufwärts. Im Moränenschutt dieses Thales, das sich vom Genje-Gebirge herabzieht, befinden sich zahlreiche polirte und gekritzte Geschiebe.»

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Barbour mentions in his paper on the physiography of the Yangtse valley that a Chengtu observer had furnished him with evidence of glacial deposits on the border of the Chengtu plain. As I considered it very probable that the informant in this case was Professor D. S. Dye of the Union University, I asked him to give me a more precise statement about this early and very important observation. In reply Professor Dye has very kindly furnished me with the following communication:

»I found glacier signs near the lamasery on the outskirts of Tsakaolao. This town is approximately 70 English miles northwest of Chengtu. Li and Tan give

it as 1930 meters above sealevel. Above and away from the river deposits, up near this lamasery now destroyed by the Reds, say, 600 feet above the stream, large and small boulders as well as pebbles are mixed as I have found them in Ohio and Wisconsin, These are of all colours and materials and laid down *very* differently from river-deposited materials. I did not note striae, but I did not look for these. This was in the summer of 1921 that I made this trip. This is the nearest glacial material with which I am personally acquainted.»

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Arnold Heim, who with his intensive research in the Minya Gongkar area has considerably deepened our knowledge of the physiographic development of Hsi Kang, denies the existence of traces of a former general glaciation of the area. The observations on striated boulders noted by Loczy, he tries to confute as having been caused, not by glaciers but by solifluction. He sums up his opinion in the following way:

»The above observations show that the former glaciers were more widely extended than they are now, but not to compare with the Pleistocene glaciation of the Alps. The former glacier tongues reached 200 to 500 metres farther down at the most. Taking the length of the present stage as 1, the former glaciers reached 1. 1 to 1. 6 (Gomba 1. 6, Yantsöko 1. 2—1. 1, Reddomain 1. 3). In the Alps, where the present glaciation is of the same type, the proportion is from 1 : 12 to 1 : 30, the early glaciation was thus twenty times stronger.»[1]

Consequently, according to Heim, there was in Hsi Kang only a local earlier extension of the glaciers (the Mosimien stage) with now abandoned terminal moraines located just beyond the ends of the present glacier tongues. All striated boulders or moraine-like deposits encountered outside these Mosimien moraines are explained away as being the effects of solifluction.

OBSERVATIONS IN 1937.

Personally I obtained no opportunity of seeing the Minya Gongkar alps which have been so magnificently described by Heim,[2] but I had a passing, yet excellent opportunity of studying another glaciated area, Minya Zara, near the road from T'aining to Tatsienlu, between the Peilokoko valley in the north and the Nomaka valley in the south. Here I noticed conditions which link up very well with Heim's observations at Minya Gongkar.

Beilokoko is a straight valley running approximately in a NW—SE direction. When entering this valley from NW you are suddenly confronted with a most

[1] Arnold Heim: The glaciation and solifluction of Minya Gongkar. The Geographical Journal. May 1936. P. 450.
[2] Arnold Heim. Minya Gongkar, Bern-Berlin. 1933.

spectacular view forming the southeastern plafond towering high above the valley, a dome-shaped, narrow-crested snowclad mountain with two glacier-tongues reaching far down its northern slope. And as you proceed southwards up the valley the glaciated mountain comes nearer and nearer, and if you camp in the southern part of the Beilokoko valley, you see in the pale moonlight, rising majestically high above all the rest of this mountain-world the snow- and ice-clad Minya Zara (Pl. XXI A).

Already when going up the valley (August 13th) I had seen from a distance at the foot of Minya Zara a wall that looked much like a terminal moraine, and the following morning, when climbing the northern slope of Minya Zara, I found that my assumption from the previous afternoon was well founded. The road zigzags steeply up this wall following a stream that brings down the water from the Minya Zara glaciers. In the cut produced by this stream it was easy to study the material forming the wall, mostly an unstratified coarse ground-moraine with local and quite subordinate intercalations of stratified material (Pl. XXII). Towards the Belokoko valley the wall exhibits a very steep slope which I estimated to be at least two hundred metres high. Apparently this is a relatively thin moraine-cover hiding the rock slope of the valley.

This moraine wall forms a tremendous accumulation running in a horse-shoe shape all along the northern base of the Minya Zara. The highest point of the moraine wall is, according to my aneroid reading, about 4 300 meters above sealevel, and the Minya Zara rises to 5 900 metres. On the NW side of the mountain we observed inside the moraine wall a beautifully turqoise-blue lake (Pl. XXI B) evidently traversed by the stream flowing in cascades down from the glacier tongues, and after its passage through this small beautiful lake reappearing in the form of the stream mentioned above, cutting through the moraine deposit. Higher up and further east there are two more moraine-dammed lakes, but they receive no water from the glaciers and consequently their water is dark and their shores boggy.

I would estimate the altitude at which the glacier-tongues of Minya Zara end at somewhat below 5 000 m (according to Heim the altitude of the snowline is 5 200—5 400 metres). As mentioned above, the highest point of the old moraines is at about 4 300 metres. Here we have an estimate of the vertical extension of the old glaciation of Minya Zara, which fits in very well with the local former glaciation of the Minya Gongkar region, the stage named by Heim the Mo-simien stage.

It is quite likely that in the Mosimien stage there are also to be included two small empty circus valleys, with terminal moraines in front, which I noticed on August 13th upon the mountain tops west of the Beilokoko valley, and which mark former circus glaciers which have now disappeared.

Thus far there is complete agreement between Heim and me in the interpretation of the glacial history of Hsi Kang. But from now on our ideas stand so

strongly opposed one to another that an understanding can be reached only by my proving to have grossly misunderstood my observations or Heim's proving to have paid too little attention to the glacial phenomena outside the Minya Gongkar region.

I shall now reproduce my actual field notes.

Zurahaki. This is a minor mountain pass almost due SW from Tatsienlu and not far from the much higher Jedo pass. 1.5 km from the Zurahaki pass there is

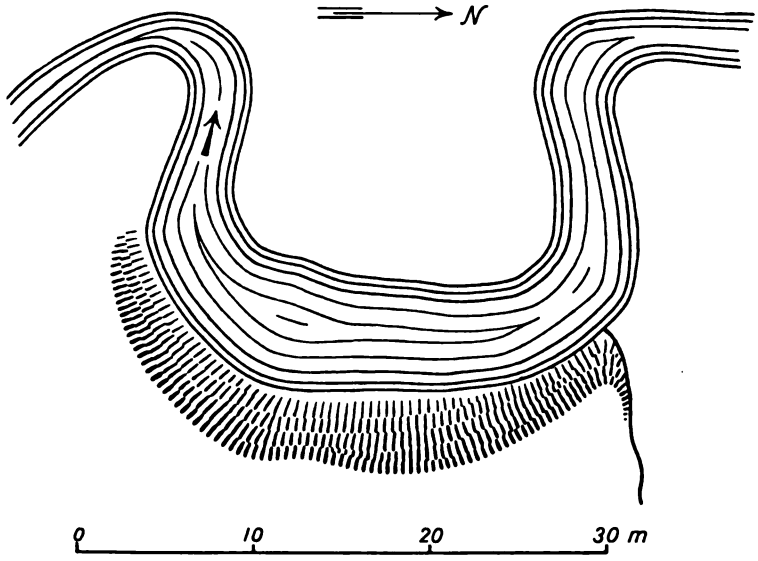

Fig. 35. The Zurahaki ground-moraine.

in the course of some sharp bends of the small southward-flowing stream Diruche an erosion cliff which to a height of eight metres consists of clayey material with rounded boulders entirely covered with striations (Pl. XXIV and textfig. 35). Some of these striae are short, curved and coarse, but the overwhelming majority are fine, straight, deeply cut striae which, so far as my experience goes, cannot have been produced by any natural agency except a moving glacier or an inland ice-sheet (Pl. XXV).

It should be noted that this ground-moraine deposit, at an altitude of about 4 000 metres above sealevel, is located in a broad shallow valley surrounded by rounded ridges rising several hundred metres above the valley bottom. This scenery of low rounded ridges, which are entirely covered with vegetation and form the principal grazing ground of the yak herds, is widely distributed at altitudes between 3 500 and 4 500 m. It is only when the mountains rise above 5 000 metres that they attain the narrow sharp crested alpine shapes which are so charac-

teristic of the real high alps of Hsi Kang. On the other hand, in the region below Tatsienlu at altitudes below 3 000 metres there are deeply cut narrow valleys with exceedingly steep sides, and between these valleys sharp ridges, often with jagged crests. It is important for our present purpose to distinguish between these three physiographic zones:

1: The region of the deeply cut river valleys below 3 000 metres.

2: The region of broad rounded hills, often separated by relatively broad and shallow valleys between 3 500 and 4 500 metres.

3: The local areas of high alps with sharp crests, narrow peaks and present-day glaciers above 5 000 metres.

We shall see in the following how these three regions correspond to three different facies of the Pleistocene maximum glaciation of the area.

S. of Kuan Chai Tzu. Some striated boulders were found in unstratified moraine-like material between T'aining and Tao Fu at 3700 metres near the places named Chi Ssu Chung and Kuan Chai Tzu in the atlas published by the Geological Survey.

The Gachala pass. But the most important observation was made when leaving T'aining on the 13th August en route for Tatsienlu. The road from Tainingl eads up through a valley, in the lower part of which there are forest-clad slopes. Upon reaching the Gachala pass, about 30 li from T'aining, I found in the road-cutting a big sandstone boulder, 0,7 metres in length with very numerous typical glacial striae running in different directions. Starting from this initial find I discovered in the small roadcuttings for a length of several hundred metres a great number of striated boulders, among them a beautiful flat boulder of black shale covered all over with fine striations (Pl. XXVI A and Pl. XXVII).

This locality (3 750 metres) is a pass leading between grasscovered rounded hills, and the find of an extensive and typical ground-moraine deposit at the very pass shows beyond doubt that the glaciation which caused these phenomena must have been a quite far-reaching one, a plateau glacier or small inland ice, very like the type of plateau glaciers which nowadays cover parts of Norway and Iceland.

We have now mentioned three localities containing ground-moraine with striated boulders:

Zurahaki (4 000 m).
S of Kuan Chai Tzu (3 700 m)
Gachala (3 750 m).

It should be noted that these three places are nearly on the same level, (3 700—4 000 m). On the other hand, together they cover quite a distance as there is about 85 km between Zurahaki in the south and Kuan Chai Tzu furthest north. Furthermore, all these places in which glacial deposits have been found belong to a very characteristic landscape, broad rounded hills and ridges, and between them open valleys mostly of moderate depth. All the country round T'aining is of this type, and sometimes when travelling among the hills we caught

a vista of this landscape of rounded hills extending far to the west beyond the area covered by us. Similarly, from a high place south of Tao Fu city, on the western side of the valley, I saw the same hilly landscape extend far to the north into regions not visited by us.

Heim has tried to prove that this hilly landscape, so well represented in his beautiful work »Minya Gongkar» (see the upper photo facing page 108, the panorama shown in fig. 15 facing page 138, and the upper photo facing page 177) is bound principally to the formation consisting mostly of black shale and yellow sandstone, whereas the high alps were built up by the big granite intrusions. This may be true, although as a matter of fact we meet at altitudes between 3 500 and 4 500 m a very characteristic high plateau with broad rounded hills, and in this landscape we have three localities where ground-moraines were observed with typical ice-striated boulders. One of these places, Gachala, was on the very top of a pass between broad rounded hills. When all these observations are combined, it seems most likely that the ground-moraines as well as the characteristic rounded forms of the mountains are all due to the action of a more or less continuous ice-sheet, an extensive plateau-glacier covering all this region of rounded mountains.

Above this once glaciated high plateau at 3 500—4 500 metres there rise some high alpine mountains, some of them exceeding 6 000 metres and one, Minya Gongkar, rising to 7 700 metres. It may be surmised that during the maximum glaciation these alps were largely covered by firn and glaciers of an alpine type. As a whole, however, they certainly rose as nunatakks out of the ice-sheet covering the undulating plateau-land below their present altitude of 4 500 metres.

After having thus outlined the physical conditions during the great ice age of the 3 500—4 500 metres undulating plateau as well as the high alps, it remains for me to trace the evidence of this maximal glaciation in the valleys below 3 500 metres. It may then be well to begin with recording my observations in the valley Nomaka leading SSE from Minya Zara.

Having passed along the circus of terminal moraines (see above p. 54) encircling the north side of Minya Zara, we noticed on the south flank of the said mountain a typical U-shaped valley, actually the only undoubted case I noticed of this feature of glacial erosion. In the following chapter on the valley erosion we shall be able to suggest an explanation for this scarcity of U-shaped valleys in Hsi Kang.

We travelled down the Nomaka valley until we reached a place, Hsin Tien, marked in the Geological Survey atlas as having an altitude of 3 500 metres. Hsin Tien is a military post built in 1936 to stem the tide of the Red army. Now the place is altogether deserted and in ruins. Immediately above the houses north of the military station rises a high wall, steep to the south and strewn with big boulders (Pl. XXVI B). This transverse wall blocks the whole valley except the narrow cut of the river. No doubt it is a terminal moraine belonging to a valley-

glacier that once filled the upper half of the Nomaka valley. To this same stage of glaciation may possibly be attributed a beautiful horseshoe-shaped wall, estimated to be at least a hundred metres high and projecting into the Nomaka valley at the mouth of a western branch valley about 70 li below Hsin Tien. To judge from the topographical features, this powerful horseshoe-wall with its convexity facing the main valley can hardly be anything but the terminal moraine of a glacier filling the side valley at a time when the main Nomaka valley at this place was already free from ice.

It now remains for me to relate my observations made much further down in these valley systems. At the beginning of our journey, when going up from Yachow to Tatsienlu, I noticed 15 li above Lu Ting Chiao, at an altitude of 1 400 metres, a transversal row of hills forming a barrier all the way across the valley except for the narrow and deep channel cut by the modern river. On the downward slope these hills are covered with huge boulders, the whole closely reminding me of terminal moraines as I know them well from Sweden (Pl. XXIII).

When going down in August, I went over this area more in detail and found full confirmation of my earlier interpretation of this transverse barrier as a large terminal moraine. I now found that these hills rise considerably above the valley bottom on the upstream side as well. They are also isolated from the right valley-side by lower land, proving that they do not belong to a dejection cone. I went out to the cliff overhanging the river channel and could see no rock outcrop in this steep slope, fully 100 metres high, cut, it seems, entirely in the young deposits.

On the other side of the river-channel, on the left side of the valley, there lies a rather large village named Ch'a Tao, and here I noticed a spur which seems to be the continuation of the barrier on the right side of the valley. When all these facts are combined I feel that there is hardly any doubt that we have here a large terminal moraine at an altitude of only 1 600 metres.

The following observations were made on the homeward journey when covering the stage between Lu Ting Chiao and Hua Lin P'ing. Near a place named Lung Pa P'u, in a washout caused by this year's summer rains, I found a number of large boulders with abundant and typical ice striae. Their matrix was quite like a boulder clay and they cannot have been washed more than a short distance. This place is at an altitude of 1 510 metres.

SUMMARY OF OBSERVATIONS ON THE FORMER GLACIATIONS OF EASTERN HSI KANG.

List of localities showing the glaciations of Hsi Kang.

Locality	Observer	Altitude	Glaciation
1. Tsakaolao	Dye 1921	1 930 m.	Gachala valley glaciation ?
2. Lu Ting Chiao	Loczy 1880 / Andersson 1937	1 600 m.	Gachala valley glaciation
3. Lung Pa P'u	Andersson 1937	1 510 m.	Gachala valley glaciation
4. Minya Gongkar	Heim 1930	3 400 m.	Mosimien
5. Zurahaki	Andersson 1937	4 000 m.	Gachala plateau glaciation
6. Hsin Tien	Andersson 1937	3 500 m.	Gachala plateau glaciation
7. Minya Zara	Andersson 1937	4 300 m.	Mosimien
8. Gachala	Andersson 1937	3 750 m.	Gachala plateau glaciation
9. S of Kuan Chai Tzu	Andersson 1937	3 700 m.	Gachala plateau glaciation
10. Gara-la	Loczy 1879	4 190 m.	?
11. Lakan-do	Loczy 1879		?
12. Rati	Loczy 1879	4 280 m.	?

Since I found in 1937 in three places within eastern Hsi Kang above Tatsienlu, in typical ground-moraines far away from the modern glaciers, abundant striated boulders of a type that is undoubtedly of glacial origin, there can no longer be any doubt that this borderland of the Tibetan high plateau was once covered by an extensive ice-sheet of the plateau-ice type so well known from Norway and Iceland.

The localities where evidence of the old glaciation was found are all at about the same altitude, 3 700—4 000 metres:

Zurahaki (4 000 metres). River section in 8 m. thickness of ground-moraine filled with typical ice-striated boulders.

Kuan Chai Tzu (3 700 m.). Striated boulders in unstratified moraine-like material.

Gachala pass (3 750 m.). A road-cut several hundred metres long yielding great numbers of beautifully striated boulders of a distinctly glacial type.

This last-mentioned locality is situated at the very top of a mountain pass leading between grass-covered rounded hills from where there is a free view over a landscape consisting of rounded ridges and between them broad open valleys, mostly of moderate depth. As the two other moraine finds were made in such valleys of this landscape of rounded hills, which I saw on two occasions extending far to the west and to the north of the area visited by me, I think it justifiable to assume that the landforms in this area are due principally to the action of the ice-sheet that covered the region at the maximal glaciation, which we may appropriately name after the most important finding-place *The Gachala glaciation stage.*

What then was the extent of this Gachala plateau-ice? Our observations have been far too scanty to outline this old ice-sheet with anything like exactness, but the following comparisons may offer some interest.

From Kuan Chai Tzu, the northernmost of my finding places, it is 84 km. to Zurahaki, the southernmost observation point upon the high plateau. From Kuan Chai Tzu to Lung Pa P'u, the southeasternmost point down in the valleys the distance is 132 km. If we also take into consideration the more doubtful observations made by Loczy and Dye, we have a distance of 400 km. between Rati in the distant west to Tsakaolao in the northeast. From general topographical considerations I consider it safe to assume 200 km. as a diametrical minimum of the area of Hsin Kang that was covered by ice during the Gachala glaciation.

If we compare this approximate figure with the size of modern plateau glaciers, we arrive at the following figures. Among the plateau glaciers of Norway Folgefonnen is 35 km., Jostedalsbräen 94 km. and Svartisen 46 km. in their largest dimension, all in approximate figures. In Iceland the largest ice-sheet is Vatnajökul, 150 km. in diameter, and the inland ice of Spitzbergen's Northeastland is 180 km. in diameter. In comparison with these modern plateau ice-sheets the ancient Gachala plateau-ice of Eastern Tibet was quite considerable; in fact very considerable, as I feel sure that a more extensive survey will show that in 1937 I covered only a minor part of the Gachala glaciation area.

So far we have considered only the plateau-ice covering the rolling hill country at altitudes of between 3 500—4 500 metres. Above this undulating plateau rise some alpine ranges and peaks to six thousand metres, and in one case even more than 7 000 m. It may be surmised that during the maximum glaciation these alps were largely covered with firn and glaciers of an alpine type. However, as a whole they certainly rose as nunatakks over the plateau-ice.

So far we have dealt only with the high plateau and the alpine peaks. But down in the deep valleys there have also been found traces of the former glaciation. For instance, in the Nomaka valley we crossed a terminal moraine (Hsin Tien) at an altitude of 3 500 m., and even much further down, below Tatsienlu, we found at Lu Ting Chiao another very powerful terminal moraine at only 1 600 m. above sea-level, and not far from this place we found at Lung Pa P'u, at an altitude of 1 510 m., huge striated boulders. These finding places are met with in narrow steep valleys framed in by narrow ridges and sharp peaks. In these cases we are certainly below the area regionally covered by the plateau-ice. These finds most probably indicate long valley glaciers forming outlets for the surplus of ice accumulated in the high plateau region.

All the finds of a former glaciation so far recorded in this chapter are to be referred to the maximum glaciation of the Gachala stage or possibly (the Hsin Tien terminal moraine) to the retreat of ice marking the fundamental change from the Gachala stage to the local glaciations of the Mosimien stage.

When we now turn to review the evidence proving the existence in Hsi Kang of a more recent and local glaciation, we have to depend very largely upon the observations of Arnold Heim as embodied in his splendid volume »Minya Gongkar» (1933) and his article »The glaciation and solifluction of Minya Gongkar», The Geographical Journal 1936, p. 444—450.

It is only thanks to this distinguished geologist that we have attained some understanding of the present day glaciation of Hsi Kang, which he not inappropriately calls »the glaciated frontier wall». The centre of this modern glaciation lies in the Minya Gongkar massif, so admirably surveyed by Heim under exceptional hardships. Another smaller group of glaciated peaks is the Tatsienlu alps, rising steeply behind the deep-cut Tatsienlu valley so that the glaciers cannot be seen from the low-lying city. A third small centre of glaciation is »The King of the Mountains», the beautiful Minya Zara, the graceful shape of which I had the pleasure of admiring during a passing visit in August 1937. Other glaciated peaks, so far not explored, are to be found in the interior even as far as near Litang (see Loczy's description above page 51).

From the centre of Minya Gongkar (7 700 m.) a number of valley glaciers descend in different directions, foremost amongst them being the Gomba glaciers to the west, the Yantsöko glacier to the north and, the largest of all, the Hailoko glacier to the east.

In the continuation of these modern ice-streams there are old abandoned moraines, indicating that the Minya Gongkar glaciers once extended beyond their present range, The greatest difference between modern glacier tongues and old moraines was found on the west side of the Minya Gongkar massif. The modern Great Gomba glacier attains a length of 10 kilometres and ends only two km. above the monastery Gongkar Gomba at an altitude of 3 800 m. above sea-level. The Pleistocene glacier of the Mosimien stage reached 8 km. farther and ended at an altitude of about 3 400 m.

The old moraines of the Yantsöko valley extend only 2—3 km. below the block-covered ice of the present time. »There the fluvioglacial terrace commences about 40 metres above the glacial river». — We shall subsequently return to this terrace which is merely an unusually beautiful example of the far-reaching Malan terraces which we have traced all the way from the western hills of Peking through the whole of Northern China to Hsi Kang.

The Hailoko glacier on the eastern side of the Minya Gongkar massif is the largest of these glaciers with a length of no less than 16 km. and it ends in the fir-tree jungle at an altitude of 3 000 metres or less. There is an old moraine 2—3 km. farther downstream.

This stage of an earlier and somewhat larger glaciation was named by Heim *the Mosimien stage* because of its supposed connection with the »fluvioglacial» terrace at Mosimien. Even if the connection of the former glaciation with the Mosimien terrace is not beyond doubt, as we shall see in the shapter on the

terraces, in the interest of historical continuity we here adopt Heim's term Mosimien stage for this final and local glaciation of Hsi Kang.

On page 54 in the description of my own observations I have mentioned the tremendous horseshoe-shaped moraine wall which runs all along the northern base of Mount Zara. According to my very approximate estimate the present day hanging glaciers of Minya Zara end at an altitude of about 5 000 m., whereas the altitude of the highest point of the moraine wall was found by measurement to be 4 300 m. This is evidently a moraine system of the Mosimien stage repeating, upon the smaller scale of Minya Zara, all the features of the former Minya Gongkar glaciation.

Among the notes on an ancient glaciation given by Loczy and here reproduced on pages 47—52 there are observations not only on the general glaciation of the Gachala stage but also notes which indicate the much more recent local Mosimien glaciation. It is hardly possible to distinguish with certainty between the two without a revision of Loczy's observations. (See table pag. 59.)

We have already assumed that the plateau glaciation of the whole area (Gachala stage) is the by far earlier oft he two. We shall be able to prove this beyond any doubt when describing the widespread Malan terraces, which were in a more recent period deposited within the area once entirely covered by the Gachala ice-sheet. The age of the Mosimien local glaciation will be more fully discussed after the terraces have been described. Here it will suffice to state that, to judge from all the evidence, the Gachala glaciation marks the very height of glacial conditions, whereas the extension of local glaciers during the Mosimien stage apparently falls towards the end of the Pleistocene.

MALAN TERRACES OF HSI KANG.

One of my great surprises during the Hsi Kang expedition was the abundance of splendidly developed Malan terraces.

The first instance I came across already at the base of the climb to the Tibetan Highland. At Yachow (Yaan), 647 m. above sea-level, we made an excursion following the right bank of the river Ya Ho downstream for a distance of about five kilometres. At a sharp bend in the river there is a most conspicuous terrace which is completely isolated (Pl. XXIX). Its name, Chai Tzu P'ing, is interesting because it contains the word P'ing, which means terrace and is the term for the Malan terrace villages of the T'ao valley in Kansu. I measured the height of the terrace and found it to be 60 metres above the adjacent river. Its surface is entirely covered with paddy fields.

At Hanyuan (1 700 m. above sea-level), about half-way between Yachow and Tatsienlu, we passed over a magnificent Malan landscape (figure 36), in which the hsien city is located. The height of the main terrace above the valley bottom is more than 50 m., but, as is seen to the right of the figure, there is an intermediate

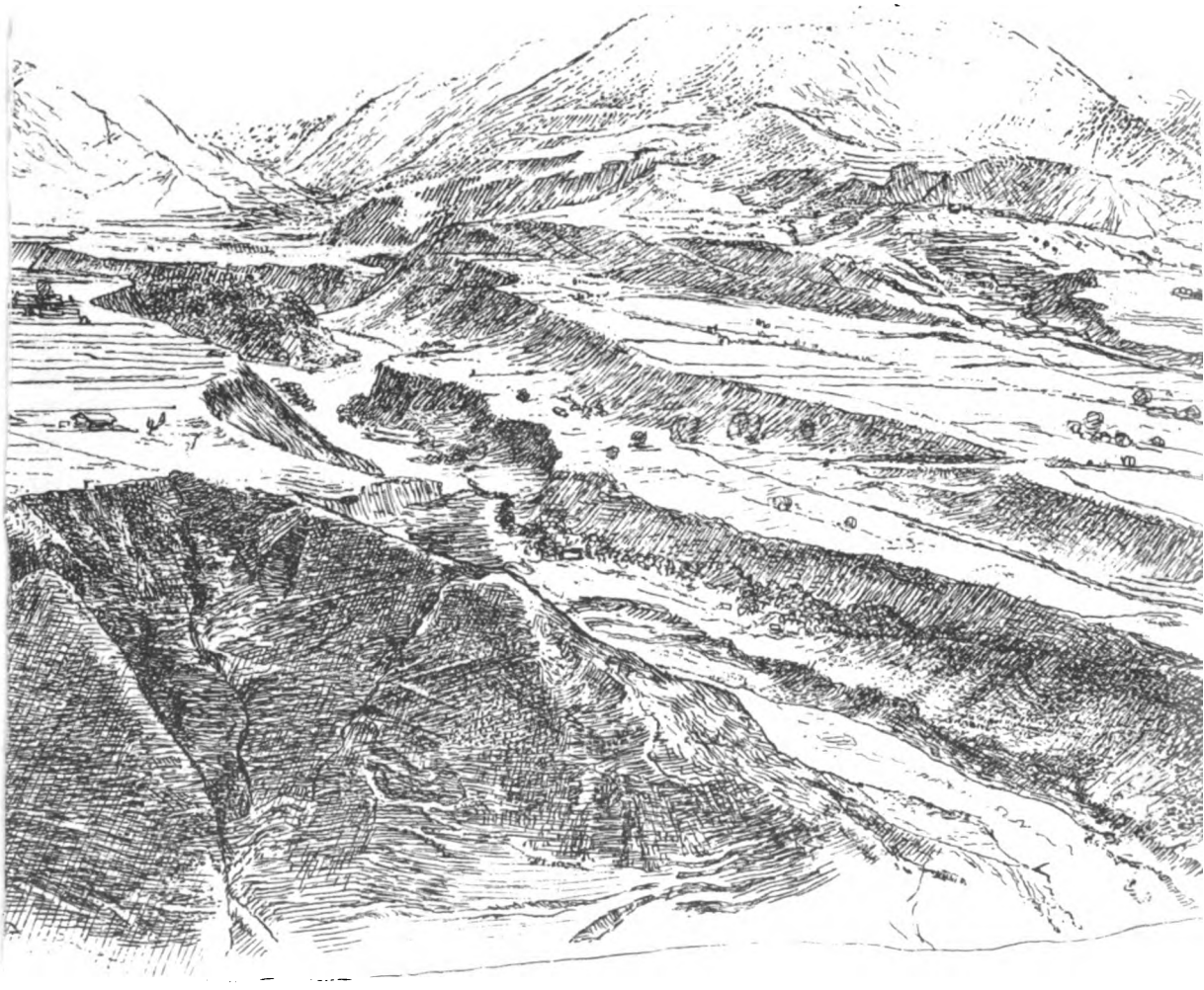

Fig. 36. The Hanyuan terra

terrace about 20 m. in height. The steep grade of this extensive terrace system is due to the spreading over the main valley of a number of alluvial fans washed out from the side valleys. This almost unique terrace scenery really deserves close examination from a physiographical as well as from an archaeological point of view.

At Hua Lin P'ing (2 200 m.) there was also observed a large terrace formation, probably well over 50 metres high and consisting of stratified gravel.

A very interesting Malan terrace was seen ENE from Ying Kuan Chai (3 490 m.). This extensive terrace is located about 13 km. from Ying Kuan Chai, ENE of the place named Watse in the atlas of the Geological Survey. It was my intention to undertake a real survey of this interesting area but I never gained an opportunity of doing so, and it is herefore with much hesitation that I present here the rapid sketch shown in fig. 37, which gives no correct contours but in principle forms a guide to the following description.

The Agato terrace has the shape of a slender tongue, the base of which is attached to a rock-hill estimated by me to be somewhere about 200 m. high. The length of the tongue-shaped terrace is about five km. Its point is narrow and sharp and directed down the valley towards Ying Kuan Chai. On each side the terrace is cut off from the valley sides by the Moumutu river to the southeast and the Abaliu river to the northwest. On the south-eastern side I estimated the height of the terrace to be only 15—20 metres, and far up on the northwestern side 25 metres.

At the foot of the 200 m. mountain there is a hill estimated at 70 m. which appeared from a distance to consist of loess. Upon closer examination this proved to be correct. One spot exhibited a thickness of 8 metres of pure indubitable loess. Thicknesses of five metres were commonly seen. Another section exhibited an intercalation of 2 m. loess at the bottom, 2 m. gravel with small slate pebbles, and at the top 2 m. loess.

At the highest part of this rounded 70 m. hill there is a remarkable monument which seems to have been used in some past epoch for some kind of worship or possibly as a meeting-place. It is a shallow horseshoe-shaped terrace, apparently formed by man, with a smaller and slightly higher similar terrace at the top. Close by are 11 stone-covered graves. (See fig. 38.) This horseshoe-shaped monument overlooks the entire valley in a very commanding way. The name of it was given as Chüniba.

Fig. 39 gives a longitudinal section of the Agato terrace with its loess cover at the base of the 200 m. hill.

Round a place called Ravaka, south of T'aining, the Malan landscape was beautifully developed (Pl. XXX). Most of the Malan valley surface is here preserved, with only a 20 metre deep Pan Chiao canyon cut down into it.

On our map 2 there is marked a place Kuan Chai Tzu, southeast of which we found some striated boulders. Kuan Chai Tzu is a single (now abandoned) Ti-

betan house, named Zono in the Tibetan language (3 780 m.). This house stands just above the confluence of two streams indicated in the atlas of the Geological Survey, and it stands upon the narrow apex of a long and narrow Malan terrace,

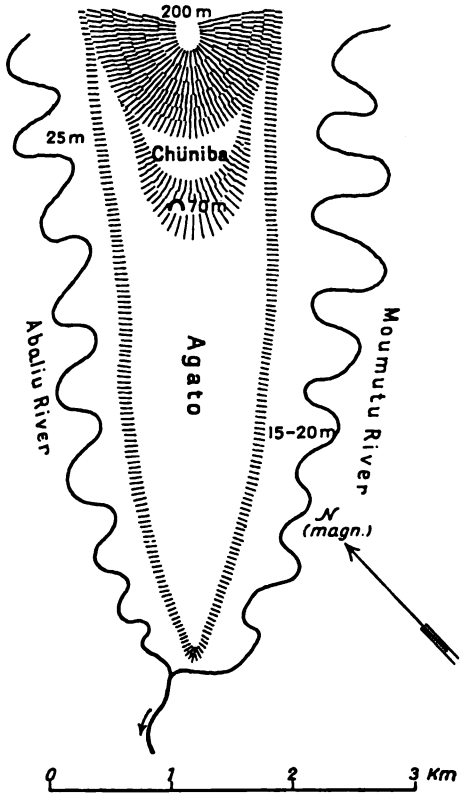

Fig. 37. Sketch-map of the Agato terrace with the loess-hill Chüniba.

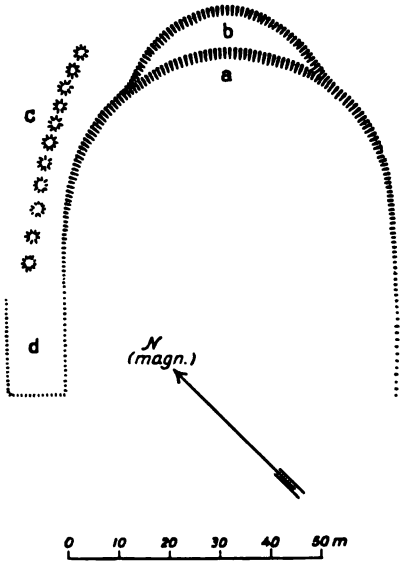

Fig. 38. Sketch of the archaeologial monument at Chüniba.

which is cut on both sides by these streams much in the same way as the Agato terrace described above. The height of the very steep ascent up the terrace south of the house Zono was estimated at 20 m.

We camped on the centre of this terrace, and the name of our camp was given as La Bren To. From here two photos were taken, one XXXI A, facing SE towards the confluence of the two streams and the house Zono. The other photo, XXXI B, is taken upstream and shows the entirely unbroken Malan valley surface, which the modern stream erosion has so far not reached.

In several places in the upper reaches of these broad open valleys there are wide expanses of a flat undissected valley bottom which reminds one of the scenery of Inner Mongolia. Such a landscape is met with for instance between La Bren To and the gently sloping Sung Lin K'ou pass.

In this connection I wish to refer to Pl. XXXII, which shows two instances in which the Malan valley surface has not yet been dissected by the stream erosion.

Pl. XXXII A is from a valley between Ying Kuan Chai and T'aining. Here some slight erosion may have occurred in post-Malan time as there are two low terrace spurs in the background. XXXII B, taken from north of Zurahaki, shows the entirely unbroken Malan valley surface dotted with innumerable spring flowers.

In the southern part of the T'ao Fu valley we discovered a large number of late Neolithic sites, nearly all located on an extensive terrace system extending

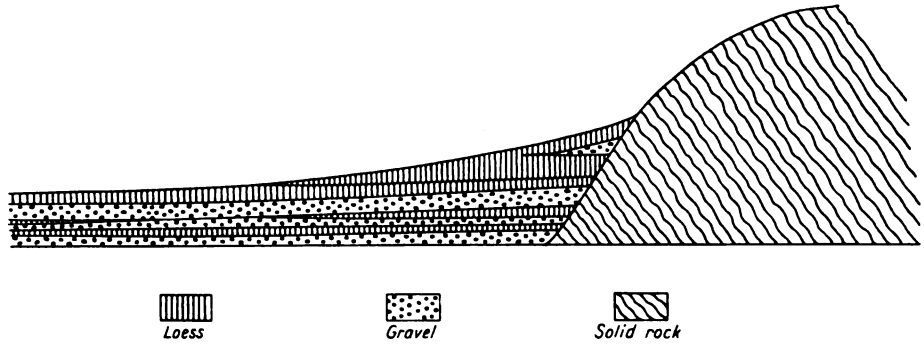

Fig. 39. The Agato terrace, near the hill overlaid by a deposit of loess.

for a distance of 8 km. from the village of Rotsung in the northwest to Cholöna in the southeast. Owing to the considerable archaeological interest attaching to this region I surveyed it on the scale of 1 : 20 000, Map 3. (reduced to 1 : 25 000). (See also Pl. XXXIII). This terrace complex is composed of a number of steeply sloping alluvial fans which have been washed out of the side valleys, their front being later on eroded by the river running through the valley. Consequently the gradient of the terrace is much steeper reckoned from the hillslope towards the river than along the longitudinal axis of the valley. Thus, Yungchi, for instance, is still upon the terrace at an altitude of 220 m. as compared with the terrace front at Kanya, 77 m., a gradient of 1 : 8. Along the longitudinal axis of the valley the gradient of the terrace is more gentle, Jendecha 120 m. as compared with Chire 51 m., a gradient of only 1 : 30. The terrace front is particularly high, about 90 metres, SE of Rotsung above the place Kunsa, but for the most part it is only about 20 m. The exceptional height of the terrace front above Kunsa is due to the existence of a very powerful dejection cone just at that place. The same rock-gorge that supplied the material for this dejection cone did produce under the erosive climate of Pan Chiao time a wild gulley which has cut down through nearly the whole of the cone consisting mostly of coarse gravel with intercalations of fine loesslike sediment and a covering of loess, less

than ten metres thick. In the other parts of the terrace complex the terrace is also built up mainly of gravel with a covering of loess some few metres thick.

It now remains to reproduce the important statements made by Heim on the existence of »fluvioglacial» terraces in the environs of the Minya Gongkar massif.

In the Pawa valley (S of Minya Gongkar) the glaciers of the Mosimien stage just came together. »There the old moraines pass into a vast fluvioglacial fan deposit, which extends far down below Pawa into the Butshu (Tienwan) valley.»

»The old moraines of Yantsöko Glacier only extended 2—3 kilometres below the block-covered ice of the present time. There the fluvioglacial terrace commences about 40 metres above the glacial river, its surface dipping 8—9 degrees in the direction of the valley. Some 4 kilometres farther down, the terrace is at 50—60 metres, dipping 6—8 degrees towards east.»

»At the villages of Lamasze and Mosimien the same fluvioglacial terrace is widely extended and cultivated. Its general slope is 5 degrees to east. The rivers on both sides have cut out deep channels down to more than 100 metres below the table terrace. The thickness of the fluvioglacial deposit in places may exceed even 100 metres. Frequently large blocks of several cubic metres are enclosed in the coarse gravel. On the surface of the terrace some granite blocks of 10—20 cubic metres were observed, and one of even 100. It is difficult to explain their position. Possibly they fell down from the slopes before the side ravines were formed.»

»On Hailoko Glacier little, if any, signs of a larger extension of the former glaciation are left in the uppermost part. Above the knee a left side moraine is preserved, which reaches 15 to 20 metres above the ice. The granite forming the knee is nicely polished up to about 20 metres. In the lower part of the glacier the left side moraine is overgrown with jungle of fir trees, larches, and rhododendron.»

»Two crests may be distinguished here, an inner one 15—20 metres above the ice, and an outer, still older one at about 25 metres. Near the glacial gate this old moraine is 60—80 metres high, but seems to reach its end already 2—3 kilometres farther down stream. No connection was seen with the fluvioglacial terrace so well traced at Yantsöko Valley. It seems that the passage zone has been washed out by side streams. But 10 kilometres farther down, at Hailoko (Chinese mountain farms), the fluvioglacial deposits are well developed.»

»The gravel terrace corresponding to that of Mosimien is at about 70—80 metres above the river. Above it two more terraces were observed. They seem to be terraces of erosion, one at about 130 and one at about 300 metres above the river.»

»The continuation of the terrace of Mosimien (Mosimien stage of glaciation) is interrupted by a granite gorge, but is recognized again along the Tung-ho. There, in the region of Shabatse, low terraces of 35 and 45 metres above the river were noted, while the high terrace is at 60—70 metres. It is the latter that seems to correspond to the widest extension of pleistocene glaciation (Mosimien stage).»

It is at once evident that these observations made by Heim in the Minya Gongkar area are of fundamental importance for the problems here discussed, not to mention the Pleistocene chronology of the whole of Eastern Asia.

On the basis of his vast experience of glacial and fluvioglacial phenomena in the Alps and elsewhere he has tried to prove a common origin and consequently

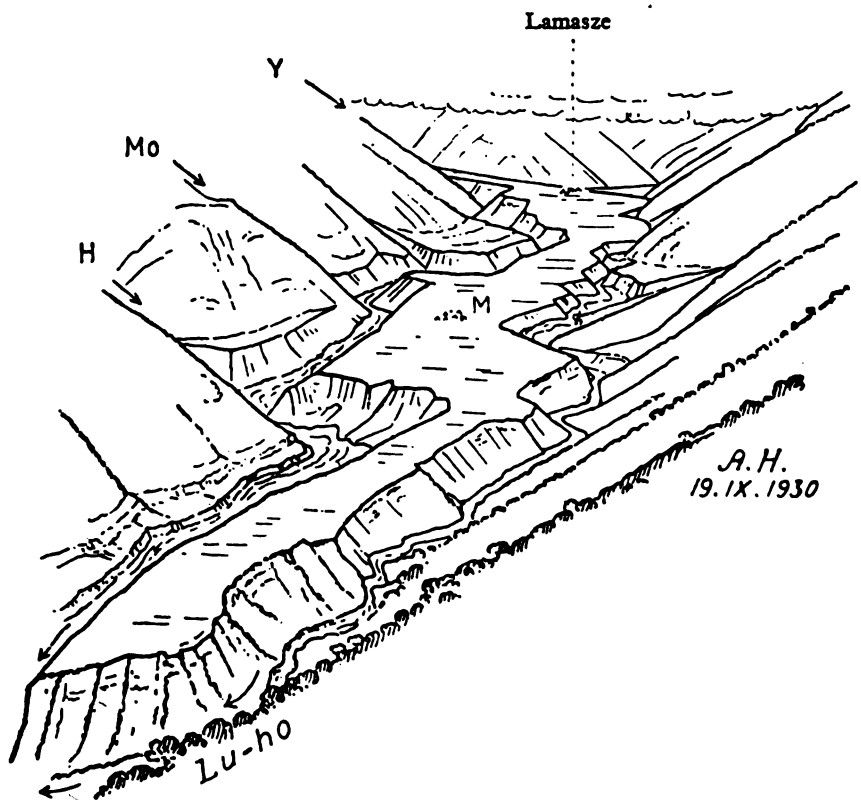

Fig. 40. The Mosimien terrace. (After Heim: Minya Gongkar pag. 95.)

a strict contemporaneity of the Mosimien glaciers and the fluvioglacial terraces following close below the ancient moraines. If this could be taken for granted, it would connect a great number of phenomena within the late Pleistocene into a definite chronological unity which would enable us to correlate the geology and the history of Early Man in Asia much more reliably with the better known time record of Europe. But the issue is of such fundamental importance that the utmost caution must be observed in discussing these problems.

Fortunately Heim's textual description is accompanied by a drawing, which is here reproduced in fig. 40, and which graphically visualizes the Mosimien terrace as a highly typical Malan terrace, a true duplicate we might say of the type locality in the Western Hills of distant Peking.

Before we go any further in discussing the Mosimien terrace as being from one viewpoint a fluvioglacial appendix to the ancient Minya Gongkar glaciers and from another a true Malan glacier, it will be advisable to dwell for a moment upon the two main types of Malan terraces.

The type locality of Ma Lan Tsun in Hsi Shan of northern Hopei offers a terrace which in Pan Chiao time had been eroded on both the mountain flanks, leaving in the middle of the valley a narrow lobe of the once continuous Malan sediment blanket. We now know of similar cases of lateral erosion at three places in Hsi Kang: The Agato terrace, the La Bren To and the Mosimien terraces. In all these four instances the effect of the lateral erosion is identical; a narrow lobe-shaped terrace has been formed bordered on each side by erosion channels following close along the rock side of the valley. It seems very probable that this queer mode of erosion was caused by the shape of the Malan valley bottom being slightly higher in the middle of the valley, so that, during the following erosion period, the streams slipped sideways down to the rockslopes bordering the valley. It is well proved in other cases that a stream that is bent upon accumulation can considerably pile up its own course. But the building up of a valley-bottom which is highest in the centre is possible only when there are no lateral tributaries but when all the load of sediment comes from the higher reaches of the valley such as is the case with all the three valleys here in question.

There is another type of Malan terrace which I came across for the first time at Lo Han T'ang in the Kueite basin. Here much of the load of sediment is washed down from the mountain slopes bordering the valley. The terrace is in this case cut, not in a continuous sediment blanket, but rather in a complex aggregate of alluvial fans sloping more or less steeply from the mountain slopes and tributary valleys. We know of such complex terrace formations in Hsi Kang, namely at Hanyuan and Tao Fu.

Both the two extreme types of Malan terraces, and the intermediary types as well, are abundantly represented in Hsi Kang, and we find them here at greatly varying altitudes from the Yachow terrace (647 m.) up to the complex Tao Fu terrace at slightly more than 3 000 metres. In northern China also the altitudes of the Malan terraces vary greatly, from the Chai T'ang terraces at 280 m. to the T'ao Ho terraces and the Lo Han T'ang terraces at 2 000—2 400 m. above sea-level.

These comparisons between Malan terraces of different types, at different altitudes and in different geographical locations prove beyond doubt that the Mosimien terrace so well described and beautifully depicted by Heim is a typical Malan terrace well within the range of those studied by me in Hsi Kang. On the other hand, our researches prove that the Malan terrace is a physiographical feature very widely spread over northern and western China far beyond the small areas in which there are traces of Pleistocene glaciations. The climatic causes which produced the sedimentation of the Malan stage had a range far beyond the small centres of the Mosimien glaciation.

For these reasons I consider it premature to accept as proved the contemporaneity of the Mosimien moraines and the Mosimien terrace as suggested by Heim. On the other hand, I do not deny that such a contemporaneity is possible. But the issues at stake in this discussion are of such a far-reaching nature that the utmost caution should be observed until further and much more detailed research has proved or disproved the correctness of Heim's conclusion. The formation of the Malan valley fillings is contemporaneous with the early part of the loess deposition which went on after these valley blankets were laid down. In the same way the Palaeolithic Man discovered by Teilhard and Licent in the Ordos desert lived there during the early stage of the loess formation but the big loess deposit rests upon the bed containing remains of Palaeolithic Man. Consequently the Palaeolithic Man of Ordos was approximately contemporaneous with the formation of the Malan valley blankets.

Furthermore, if those blankets of sediment were contemporaneous with the last and very restricted glaciation of Hsi Kang — as suggested by Heim — then we should possess a most powerful means of correlating the Pleistocene history of Eastern Asia with the far better known Pleistocene timetable of Europe.

There is one more feature in the terrace formations of these Hsi Kang valleys which should be mentioned here. In a few rare places there are terrace spurs preserved high up, even as high as 200 metres or more, above the present valley bottoms. In many cases such spurs may not indicate valley bottoms older than the Malan stage. Such is certainly the case with the scenery shown in Pl. XXVIII A, where the elevated spur visible in the centre of the picture is nothing but part of the steeply sloping Malan-time gravel accumulation in the side valley.

Nevertheless, there remain a few very highly elevated terrace spurs which I consider to belong to very ancient valley bottoms which have survived the maximal glaciation (the Gachala stage). On the other hand, in Hsi Kang as as well as in Kansu and in Hsi Shan of Peking there are very low terraces of apparently very recent age. But these old lofty terraces and recent, very low terraces are both quite insignificant when compared with the abundant and extensive Malan terraces which in some places entirely dominate the landscape.

That the Malan terraces were formed long after the Gachala plateau-ice had dissappeared is beyond doubt. Their relation to the Mosimien glacial stage can hardly be fully elucidated until the Minya Gongkar and similar glaciated areas have been carefully surveyed for the purpose of solving this fundamental problem.

SOLIFLUCTION AND DEVELOPMENT OF THE VALLEYS.

Geologically speaking, Hsi Kang is a young country. The sedimentary rock-ground ranges from Permian to Cretaceous. The granite intrusion is as recent as Tertiary. Tectonically the area is a fracture zone dividing the Szechuan lowland from the high Tibetan plateau. Consequently some of the valleys, such as the

Tao Fu valley, are rift valleys on a small scale, straightcut narrow blocks of the rockground which have become submerged between nearly vertical faultlines. The seismic conditions are very unstable. Violent earthquakes are common and hot springs frequent. The variations of altitude are quite astonishing. From the top of Minya Gongkar to Mosimien, a distance of only 28 km., there is a vertical difference of no less than 6 100 m. Even within the valleys the gradient is astounding: from Tatsienlu to Wassukou there is a fall of slightly more than a thousand metres in a distance of 25 km.; all the way the river is a white foaming torrent.

No wonder that these mountain streams have a very high erosive and transporting power; in fact only very huge boulders are visible in the midst of their channel. But the process of erosion in these valleys would be only very imperfectly understood if we did not fully estimate the restless work carried out by violent earthquakes, landslides of varying velocity and, last but not least, by solifluction, the slow, almost imperceptible wasterceep, the movement of stone-loaded mudmasses saturated with water and in other seasons pushed on by the repeated alternations of frost and thaw.

In his book »Minya Gongkar» (figs 112, 114, 121) Heim has given us some interesting photographs of the violent earthquake which befell the Tao Fu valley on the 24th March 1923.

The landslides are caused partly by the exceptionally steep slopes of the mountains bordering the narrow valleys, partly by abundant rains, which saturate the soil and turn it into a semifluid substance which moves down the slope much like porridge.

Pl. XXXIV right shows our crossing of such a moving landslide. The picture very clearly indicates the steepness of the hillslope, the fast-flowing river immediately below and the moving sticky, stone-laden mud over which we are passing with extreme caution. Note also the patches of vegetation which are carried along, turned and twisted and locally swallowed by the semifluid mass. This photo I took NW of Tao Fu city on the left side of the river between the places Chungda and the gold-mining centre Chiang Chun Ch'iao. Here we passed three such treacherous stretches of moving soil. When we returned over the one here photographed three days after marching up river, parts of our earlier track had slipped down into the river and we had to cross as best we could, walking over the sticky and slippery mud.

The landslide just described was a slow one, which we had to pass, still with great caution. On the 21st August, on our return journey from Tatsienlu we had a very strange experience when going up to Hua Lin P'ing. To our right the slope was very steep and covered with deep masses of debris. Half of the caravan had already passed what later proved to be the danger spot when one of the soldiers in the escort fired his rifle. Instantly, owing to the slight air vibration, a body of soil containing huge stones broke loose and came *flying* in big bounds across

the road. For a quarter of an hour we were held up with huge boulders bouncing all the time across our track.

The exceedingly steep and waste-loaded valley-sides are in many places more or less subjected throughout their extent to slow imperceptible solifluction and landslides. Often I estimated fifty percent of the slopes to be covered with slow landslides actually *en route*. As a rule this kind of landslide begins high up on the slope with the formation of a horseshoe-shaped rift in the covering of grass.

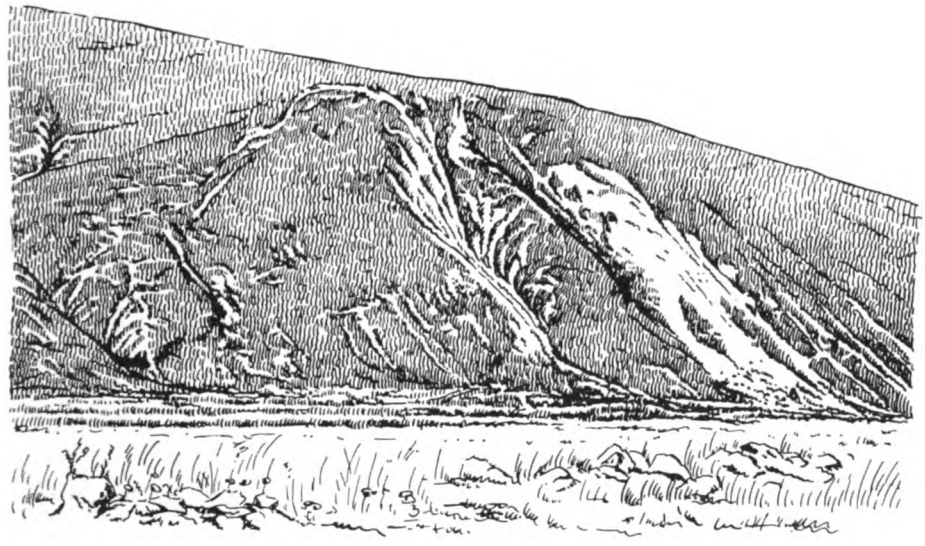

Fig. 41. The formation of slow landslides. Tao Fu Hsien.

From this initial stage the movement goes on, while distorting the vegetation-cover, until finally the whole depth of the slope is swept clean of plant life and the waste removed has been discharged into the powerful whirling current of the river. Fig. 41 illustrates both the beginning and the end of this process. The left half of the picture shows the initial horseshoe rift in the early stage of formation, to the right a whole area has been cleared of vegetation except forsome patches of the grass-cover, which are on their march downhill.

Fig. 42 shows a slope covered with a network of solifluction mudstreams, which under torrential rains are turned into small brooks.

Thanks to the abundant rainfall, specially in the high mountains, all the erosive agents, solifluction, landslides and the direct cutting activity of the swift waters, are exceptionally active. All these valleys are being constantly and actively reshaped. Under these circumstances it is but natural that the traces of the old mid-Pleistocene Gachala glaciation should be only locally preserved. The huge terminal moraines of Lu Ting Chiao and Hsin Tien are traversed and largely

removed by deep erosion channels. The ground-moraines are constantly being reduced by river action and the very shape of many valleys has been transformed through vertical deepening, assisted by landslides upon the slopes, into V-shaped valleys owing to the erosive action of running water. Only in one single place south of Minya Zara did I see a typical glacier-eroded U-shaped valley.

Fig. 42. Solifluction and torrential brooks. Between Zurahaki and Ying Kuan Chai.

NEOLITHIC MAN IN HSI KANG.

During my extensive archaeological reconnaissance in Kansu in 1923—24 I found that the Neolithic sites, that are so common and so rich, were in this area closely connected with the Malan terraces. It is true that in the Sining area the sites were mostly found upon level ground, and that some of the Kueite sites also occurred nearby and only a few metres above the Yellow River.

But in the area of Lo Han T'ang of the Kueite region the sites, especially the rich Lo Han T'ang W site, is a highly typical terrace site, even to the extent that it is placed upon an isolated terrace lobe which must have served as a natural fortification, making access to this Yang Shao site difficult and dangerous to an enemy.

When in the spring of 1924 we entered the T'ao valley, a very Eldorado for the archaeologist, we found here the closest relationship between the terraces and the prehistoric settlements not only of the Neolithic but also of the early Bronze Age. The prehistoric peoples of T'ao Ho proved to be veritable *terrace*

dwellers, with such remarkable locations as the pre-Yang Shao village of Chi Chia P'ing and the Bronze Age station Hui Tsui, the first located upon a nearly detached lobe and the other upon an entirely isolated island of the magnificent Malan terraces.

When I travelled in Hsi Kang and there came across an almost unrivalled development of the Malan terraces, it was only natural that I should look for Neolithic pottery on these terraces. In the lower levels, as for instance at Yachow and Hanyuan, no finds were made for the very practical reason that the level surface of the terraces was entirely covered with paddy fields, which made the search for prehistoric remains rather difficult.

The first place where we found sherds of prehistoric pottery in Hsi Kang was the Agato terrace, but the material there was very scarce.

Only when we entered the Tao Fu valley did we make archaeological finds of considerable importance. Here for a distance of 8 km. we came across a large complex of terrace deposits of the alluvial fan type described above, and all along the escarpment of this terrace one group of important sites after another was discovered. This area of prehistoric sites proved so important that I undertook a regular survey of the whole area (Map 3). At the end of our reconnaissance not less than 17 sites had been revealed. Furthest NW are the three Rotsung sites (for Rotsung 1 see Pl. XXXIV left). Then follow the four Chire sites and the six Kanya sites, Nos. 5 and 6 among which proved the richest of the whole group. Of the 17 sites within the Rotsung-Cholöna terrace complex all are located near the front of the terrace, the only exceptions being Zu Wo and Yungchi, which are high up on the more elevated reaches of the terraced fans, and the Yibi site, which is located on the low land near the river.

No painted pottery was ever discovered in any of these sites. The innumerable monochrome sherds which we came across are of two types, which may mark different Neolithic cultures; one red, represented mostly by small sherds occurring in great numbers, and a grey ware of which also large fragments were found. Most of our excavations were undertaken in the deposits containing the grey pottery, together with which we found among other stone implements, tools or arms elegantly cut in slate and possessing shapes hitherto entirely unknown. As a whole the Hsi Kang Neolithic seems to form a province of its own. These features will become better known when Dr Chi Yien-Pei of the Academia Sinica, who supervised the excavations, has published his monograph on this material.

ARCHAEOLOGICAL RESEARCH IN THE FAI TSI LONG ARCHIPELAGO. TONKIN

PREPARING THE FIELD WORK

In October 1937 I returned to Shanghai via Hankow, Canton and Hongkong from a summer expedition in Eastern Tibet. The long détour had been necessitated by the deadly struggle in which the two main Powers of the Far East had engaged. When travelling down to the South China coast in the midst of air attacks upon the big Chinese cities, I felt that I should like to spend my last field campaign in the Far East somewhere entirely outside the area of the great conflict. With this object in view, on the 4th October I addressed from Hongkong a letter to M. George Coedes, Directeur de l'Ecole Française d'Extrême Orient in Hanoi, asking whether I might be allowed to participate in the field work carried out by that archaeological Institute. In the most hospitable and charming spirit M. Coedes invited me to come to Hanoi to discuss with him the plan for the field work suggested by me.

On the 28th December I arrived at Hanoi accompanied by my assistant, Miss Vivian C. Dorf and my veteran servant Chuang, and on the following day I had the pleasure of meeting M. Coedes, who received me with the utmost courtesy and suggested several regions offering prospects for prehistoric research. Among them we very soon decided to choose for my brief period of field work the archipelago extending E. of Haiphong between Port Courbet and Port Wallut. As this region could be reached by motorcar in three hours and there was a good prospect of obtaining motorboats or orther fast craft for the reconnaissance among the islands, it was thought probable that the short time available could here be utilized to the best advantage.

After a brief period of organization work we started on the 15th January from Hanoi for Hongay, the coal-mining port which, together with Vachai, froms the established point d'appui for scientific research in the Fai Tsi Long archipelago.

When I now look back upon the two months and a half which I spent so profitably and under such pleasant circumstances in this unique archipelago,

my thoughts go naturally in the first place to the Director of the Ecole Française d'Extrême Orient, M. Coedes, who from the first moment received me in such a courteous manner and then untiringly supported me with all the means of his splendid Institute. May I take this opportunity to present to M. Coedes the expression of my profound gratitude. My thanks are also due to M.Victor Goloubew, the distinguished expert on the early bronzes of Tonkin, who with that spontaneous kindheartedness which is admired by all his numerous friends did so much to guide me in this to me unknown field.

It has also given me quite special pleasure to meet Mademoiselle M. Colani, the venerable and deeply learned Prehistorian of the Ecole. Dr Colani began, as was the case with me, as a geologist, and for this reason we had a common and in many ways advantageous platform from which to review the archaeological finds. Our visit together to the Fai Tsi Long sites on March 28—30 gave us many an opportunity for fruitful discussion, and Melle Colani contributed most valuable data to the understanding of the once so mysterious »Coquille des Grottes».

Among the officials of the Ecole I wish to mention also M. Réné Mercier, Keeper of the Musée Finot and Manager of the technical affairs of the Ecole. The willingness and skill with which M. Mercier replaced our wornout equipment and later helped us in all practical matters very materially contributed to the success of our work.

To still another member of the staff of the Ecole I owe a debt of gratitude. M. Nguyen ngoc Trân, Dessinateur de l'Ecole, was commissioned by M. Coedes to go with me as interpreter and assistant in practical matters. M. Trân soon proved to be such a valuable help that I was able to entrust to him the leadership of the very extensive excavations, thus reserving for myself freedom to devote my time to the surveying of the sites and carrying out such special scientific research as has much improved the value of our field work. The pleasant personal cooperation and the perseverance and minute care displayed in his important routine work distinguished M. Trân as the best field assistant I have ever had during my many years of field work in the Far East.

To a very distinguished resident of Haiphong and Vachai, Capitaine P. A. Lapicque, I wish to express my admiration and profound gratitude. Before my start from Hanoi M. Coedes had told me about this admirable pioneer and advocate of the future of Port Courbet, the natural port of Tonkin. And the Director had also asked this gentleman by telephone to assist me in my work. The unparalleled extent to which M. Lapicque and his family put their home and all their resources of vessels and men at the disposal of myself and Miss Dorf has for ever made us feel ourselves their debtors and admiring friends. At the moment of departure all my best wishes go to these brave and enterprising people who work so enthusiastically and with such singular success to develop that charming little paradise, l'Ile aux Buissons.

THE RECONNAISSANCE:

The archipelago with which we intend to deal in the following pages fringes the northern part of the coast of Tonkin not far from the Chinese frontier. Its western end with the largest island — Cat Ba — is situated 30 km due east from Haiphong. This western part of the island group, one of the principal tourist attractions of Tonkin, is mostly spoken of under the name of Baie d'Along, but the other large open water inside the archipelago, the Baie de Fai Tsi Long is much more centrally located within the island group — which for that reason I have named here the Fai Tsi Long archipelago.

So far the Ecole Française d'Extrême Orient had not undertaken any archaeological reconnaissance in this part of Tonkin, and no antiquities older than Sung were known to occur there. Consequently I was here entering a virgin field and had to figure out how to unravel the sites that might possibly exist here. The geological structure of the region, with which I was made familiar by the kind help of the acting Director of the Service Géologique de l'Indochine, M. E. Saurin, showed that the large island Cat Ba and hundreds of small »ilots» in the western part of the archipelago are built up of a limestone formation. Photographs, especially photos taken from the air by the Air Force of Indochina and kindly put at my disposal by Capitaine Courtelhac, proved that these islands had more or less vertical or at any rate very steep slopes. Consequently, in the limestone area there was little chance of finding sites in the open, but there were splendid prospects of cave finds. Primarily for the purpose of the reconnaissance among the limestone islands a small flotilla was organized consisting of the steam launch »Le Touriste», an open motor boat and two sampans, and with these craft we scanned the limestone cliffs right through the archipelago during the second half of January and the first half of February, a time during which »le Crachin», the winter fog, made life miserable. During these weeks we visited about fifty caves ranging from the large famous Cavernes well known in the tourist world down to small grottoes, often so difficult of access that we had to climb and descend by the aid of ropes.

We soon found that the large famous grottoes, so appealing to the lay mind, offered very little of interest to us. The only large cave of great archaeological importance was the cavern upon l'Ile des Grottes north of the big Ile de l'Union (PL. XLIII, XLIV). This cave, which we named from our first beautiful find — *Grotte du ciseau* —, proved to harbour the most important deposit of that strange sediment described below as a kitchenmidden consisting almost exclusively of the mysterious »Coquille des Grottes». But such much-spoken-of caverns as the large caves of l'Ile des Merveilles and l'Ile de la Surprise, names which reflect the fame of the caves, proved quite uninteresting from our point of view. These immense underground rooms had a floor of hard red loam, probably the residue from the solution of the limestone. But this sediment proved entirely sterile, apart from some bat bones.

The caves that proved to be of archaeological importance are as follows: —

1. Cave upon the eastern islet of Les Jumeaux.
2. Cave upon Le Selle, SE. from l'Ile des Merveilles.
3. Cave upon l'Ile du Crucifié; SW. from l'Ile Madeleine.
4. Cave upon La Poire, near the western end of l'Ile Rousse. Named *Grotte des Huitres.*
5. Cave upon a small islet to the east of the Ile de Brandon group. Named *Grotte des Coquilles.*
6. Cave in Port des Sylphes. This was named by us *Grotte des Sylphes.*
7. Cave upon l'Ile des Grottes, a small ilot N. of l'Ile de l'Union. Named *Grotte du Ciseau.*

The first four caves were found to be of minor importance; the three last-mentioned proved very important, as the following description will show.

The north-eastern part of the archipelago consists of sedimentary rocks other than limestone. A quite different topography prevails, long crests from which gentle slopes run down to the sea shore. Here there are possibilities of finding litoral sites in the open, more or less under the same topographical features as those which characterize the Hongkong sites.

On the morning of January 25th we landed upon the extensive plage forming the southern shore of l'Ile Danh Do La. We brought with us a stone axe to be shown to the local natives and soon no less than five axes had been bought from various villagers. As no information could be obtained as to the provenance of these axes, I had to use topographical features for tracing the site, and I soon decided upon a low rocky spur nearly in the centre of the island. Very fortunately for us, a small trolley-way had been built to a sand pit for quarrying glass sand, and in a cutting made for this railway I found a very distinctive layer over- and underlaid by barren sand and containing immense masses of pottery apparently of a prehistoric type.

When this find was made known to our friend M. Lapicque in Vachai, he sent two of his men to inquire for stone implements round Port Courbet, and his reconnaissance met with such singular success that a number of stone implements were gathered from two places where we later located two rich sites quite similar to the Danh Do La type, one named Dong Mau and the other Xich Tho.

THE ORIGIN OF THE LIMESTONE ISLANDS AND THEIR CAVES

Before we proceed to describe the different sites it is desirable to outline the origin of the very strange — not to say unique — topography of that part of the archipelago which is built up of limestone.

PL. XXXV, the photograph kindly placed at my disposal by Capitaine Courtelhac, gives a very good general idea of this strange island world. Large islands, as well as very narrow islets, rise 100—200 m. out of the sea with very steep,

often vertical and sometimes slightly overhanging walls. They consist of a very hard grey massive limestone which is marked in the Carte Géologique de l'Indochine Française published in 1937 as »Ouralien et Permien». As a rule this limestone is very massive, with sometimes only faint indications of bedding planes. In most cases it is still quite easy to establish the inclination of the beds. Often the limestone rests almost horizontally, but quite close to it the inclination may be fairly pronounced. Occasionally there are distinct faults within the limestone formation, as shown in fig. 43. In some rare cases even folding was noticed. The sharp folding shown by some rocks on the foreshore at the

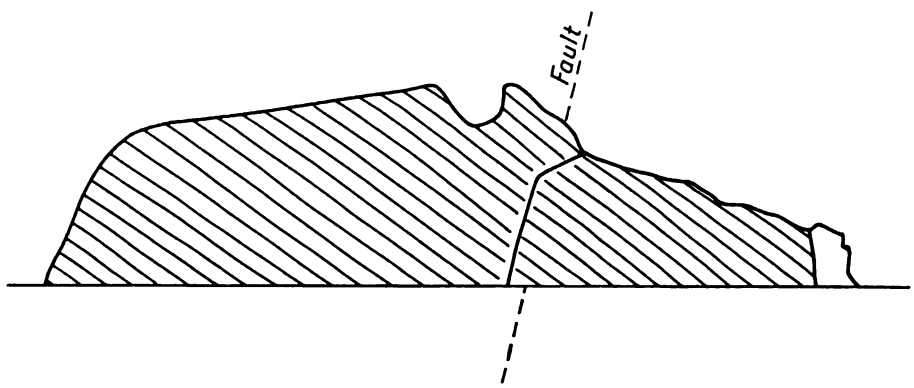

Fig. 43. Small limestone island in the Brandon group showing distinct fault.

northeastern mouth of Port des Sylphes may possibly be a local and secondary phenomenon connected with the faulting, which is apparently very strong in that area.

At any rate, the tectonic features are very varied and the development of the caves is in no way dependent upon the horizontal or inclined position of the beds. On the contrary, some of the horizontal large caves cut through the inclined strata in a most independent way, as is the case with both the Grotte des Coquilles and the Grotte du Ciseau (fig. 60). Otherwise the frequency of grottoes and caves is dependent upon the condition of the rock. First of all, the caves are naturally best developed where the limestone is quite massive. In those parts of the limestone series where the rock is distinctly stratified and locally even thin-bedded the caves are not well developed.

A factor of the highest importance for the development of one type of caves is the vertical cleavage of the limestone formation. The powerful vertical diaclases south of Ile des Merveilles, for instance, are so strongly developed that it took me a good deal of careful study not to mistake it for a vertical dip of the strata. In not a few cases vertical cavities have been formed by the dissolution of the rock along such a diaclase or a group thereof. These vertical caverns, often

partitioned by stalagmite formations into two- or three-storied structures, are picturesque and at the same time difficult of access. To us they proved to offer no archaeological interest.

Many of the big caves are — so to speak — equi-dimensional; they have a horizontal extent of sometimes one or two hundred metres, but at the same time a considerable height of several tens of metres, maybe sometimes as much as fifty metres. An equi-dimensional cave of small size is the — in several ways — remarkable Grotte des Sylphes, in which all the three dimensions are of the same order (Map 5).

The other extreme type is the horizontal cave, as for instance the modern Grotte du Ciseau (Map 4) and the old Grotte des Coquilles, in which the horizontal extent is many times greater than the relatively small height of the cave (Pl. XLVI and fig. 57). As both these caves are only some few metres above sea-level in both cases the sediment-bottom of the cave is, at the lowest point, only a metre or less above high-water level. The strictly horizontal extent of the cave rooms and the approach of the floor to sea level proves that the hollowing out of these chambers took place very nearly at the same sea level as at present. The dissolution of the limestone was eventually caused by the dissolving action of fresh water trickling through fissures in the limestone formation. Nevertheless, the general outlay of the cave, and especially the flooring, must have been entirely under the sway of the adjacent sea surface.

But there is a further possibility that the horizontal caves are being cut by the action of the sea-waves combined with the relentless work of the tide. And here it will be necessary to dwell for some time upon the marine erosion, as it is taking place in the Fai Tsi Long archipelago. In the Baie de Tonkin there is only one high and one low tide every twenty-four hours, with a vertical difference that may be estimated at something round one and a half to two metres. This rhythmic rising and falling of the sea-surface combined with the action of the waves has produced upon the easily dissolved limestone a number of very important erosion phenomena.

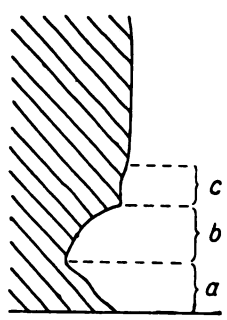

Fig. 44. The levels of marine undercutting.

One of them is everywhere present and is well shown by Pl. XXXVI, XXXVII and fig. 44. It takes the form of a horizontal undercutting made by marine erosion and fringing nearly every one of these limestone islands to a height of two metres and more if the uppermost faint trace of the erosion is counted, Pl. XXXVII. This horizontal erosion undercutting may be subdivided into three subzones (f. 44). Nethermost is a brown band (a) with numerous white spots from the innumerable oystershells which more or less cover this basal subzone. In figure 44 this subzone is shown projecting forward but not seldom infrequently it retires together with the next zone. This zone (b) is generally grey in colour and is always

receding, as is shown in the figure. Above these two subzones showing the maximum erosion there is, to the height of less than a metre but locally, on exposed places, much higher, a subzone (c) indicating the last faint action of the spray from the waves (Pl. XXXVII B). The horizontal depth of this undercutting is often two to three metres, but locally, especially upon points exposed to strong wave action and to double side attack, it may be five metres or more. In many places this horizontal erosion undercutting is quite regular, running as a dark uniform band encircling the island. But in other cases it is much more irregular with deep hollows between the less eroded parts. In many cases it is easy to see how these hollows are formed upon diaclases or upon less resistant bedding planes where the dip of the limestone is steep.. On the other hand, there are hollows for which there is no visible line of attack and these are often the most important,

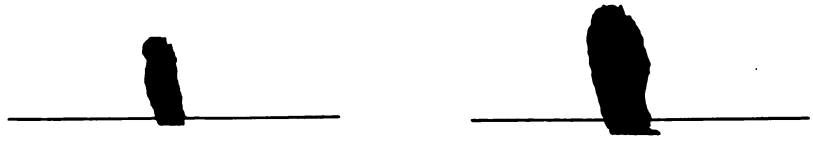

Fig. 45. Fai Tsi Long, a lone limestone pillar seen from two different viewpoints.

forming in fact real caves filled with sea water during every high tide. When writing this report I regret that I did not spend some time in measuring and surveying these tidal caves, which seemed useless from an archaeological point of view but may have offered important facts to the solution of the cave problem. We shall return to this discussion when describing below the »Cirques» and their vital importance for the whole erosion process in the limestone area.

So far we have discussed the formation of the caves under the tacit assumption that the limestone islands remained unchanged when the caves were formed. However, this was by no means the case, and it will be necessary to go further and discuss the whole erosion process within the limestone area.

Many of the smaller islets are of columnar shape, the height being much larger than the diameter. A famous instance is the Fai Tsi Long in the northern part of the bay of the same name (fig. 45). But there are hundreds of others of the same shape especially out towards the open sea (fig. 46, 47), and this shape forms one of the final stages in the erosion of an islet which will sooner or later be overturned by the waves and broken to pieces in the fall.

In this connection I wish to throw some light upon some side issues in the life history of these limestone islets.

In very sheltered places where the heavy swell cannot enter, the erosive action is mainly chemical and such exceedingly fanciful rocks are formed as those shown in fig. 48.

Fig. 46. Limestone pillars near the open sea.

In the higher part of the limestone islets, which the marine action cannot rearch, fanciful slender pinnacles, such as are shown in Plate XLII and fig. 49, 50, are formed through subaerial chemical action.

Last but not least, some remarks are called for on the ultimate downfall and destruction of these limestone pillars. Every year some of these columnar limestone rocks collapse under the pressure of the waves. Very often they are broken up into several blocks, each of which, where they lie, undergo the combined chemical and mechanical marine erosion as described above.

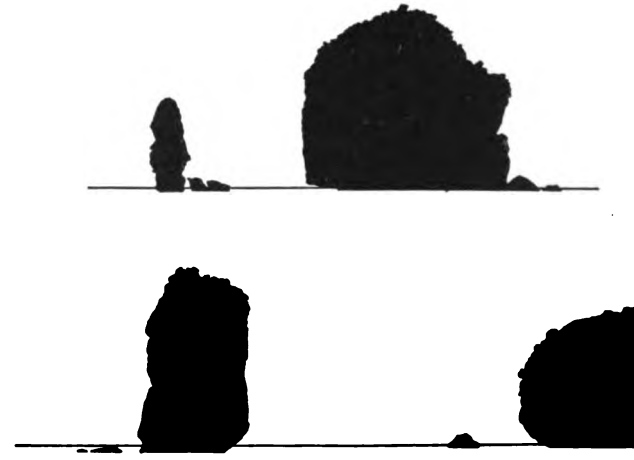

Fig. 47. Limestone pillars near the open sea.

A most conspicuous case is *Le Crapaud* in the southern part of the Rade du Crapaud (fig. 51). In this case the fantastic and highly suggestive shape is probably due to a local steep dip of the limestone.

There are many features in the topography of this island world which have nothing to do with marine erosion. The rounded and wooded summits of most of these islands — as well as many slopes equally forested — are due to quite different forces. In order to see this clearly it is only necessary to study the topography of the upper and inner parts of the large limestone island Cat Ba, regions which in modern times have not been reached by marine erosion. Here we meet the same narrow and sharply rounded tops of the hills, the same wooded steep slopes. It is a landscape characteristic of massive limestone formations, a landscape that has been well depicted by Etienne Patte in his work »Etudes Géologiques dans l'Est du Tonkin». Bulletin de Service

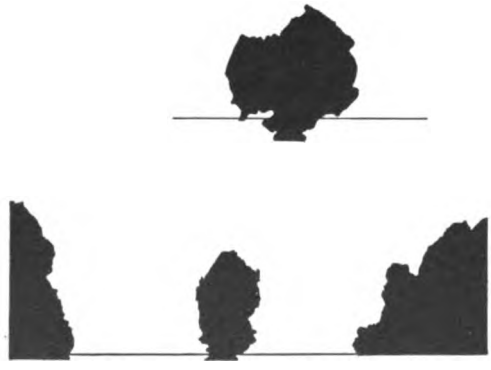

Fig. 48. Fanciful limestone islets formed in sheltered places.

Géologique de l'Indochine 1927, P: 12: »c'est le type des pays karstiques avec rochers déchiquetés, cannelés verticalement par l'érosion, cirques pertes de ruisseaux, résurgences, grottes, etc.»

This graphic picture, referring to the Bac Son limestone area further north in the interior of Tonkin, can well be applied to the interior of l'Ile Cat Ba. The Baie d'Along and Fai Tsi Long archipelago is merely the lower part of the same

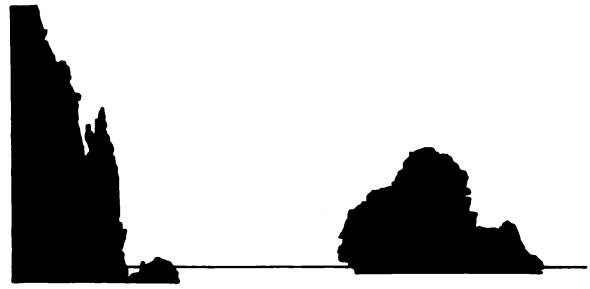

Fig. 49. Islands crowned by fanciful slender pillars.

Fig. 50. Islands crowned by fanciful slender pillars.

Fig. 51. »Le Crapaud» (the toad), one of the most conspicuous limestone rocks.

large limestone area, a region partly submerged under the sea and exposed to the combined effects of subaerial and marine erosion. The narrow rounded hilltops, as well as the steep slopes of the small islands, offer exactly the same topographical features as those seen in the interior of Ile Cat Ba, quite out of reach of the action of the sea. Such a strawberry-shaped islet as that illustrated in Pl. XXXVI has no more marine features than the very regularly shaped horizontal cut at the base; all the rest is a product of subaerial karst erosion such is seen in the interior of l'Ile Cat Ba. From an entirely inland form such as that in fig. 52: 1 we arrive at the »La Fraise» form, 52: 2, and in other instances we meet more advanced marine forms such as 52: 3, closely similar to figs. 45—47. It is the horizontal undercutting by marine erosion that causes the scaling-off of the full rounded forms of the strawberry stage. That the collapse of the strawberry-shaped slopes is going on at a considerable speed was evidenced by an

entirely fresh scaling-off from a rock not far from l'Ile des Grottes. At the beginning of March this hill still maintained its vegetation-covered slope. But when we returned there on the 29th of the same month, the whole hillside had fallen down, exposing an intirely fresh cut in the limestone.

This process of undercutting by means of marine erosion and the subsequent collapse of parts of the hill-walls form one of the important agencies in reshaping and final reduction of these islands. But there is another form of erosion which is possibly just as powerful, even if its work is less conspicuous at first sight. This component of the complex erosion process requires some detailed description.

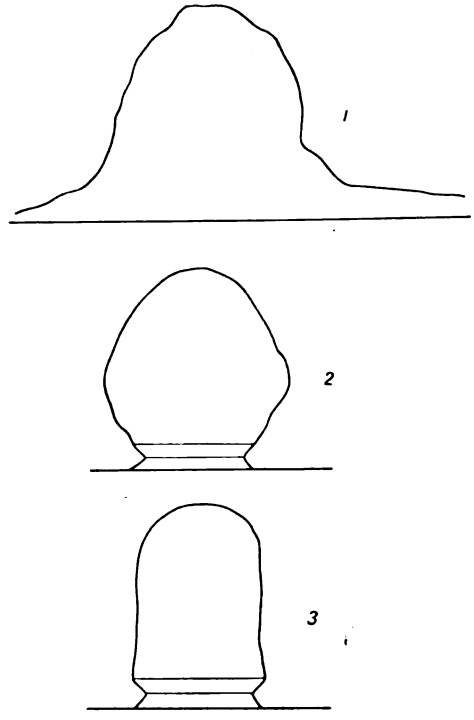

Fig. 52. Development of the limestone pillars.
Stage 1. Inland limestone hill.
» 2. Strawberry chape caused by marine undercutting.
» 3. Pillar shaped by scaling off overhanging garts of the strawberry stage.

When first studying these islands I was struck by their irregular and sinuous contour with deep bays, some of them nearly landlocked (see fig. 53—54). Later on I often found myself thinking that there must exist a great number of entirely closed basins inside these islands without any visible outlet whatsoever. Time and again I saw a low limestone wall and behind it a higher one, but there was no way into the space that must exist between the two. Similarly, on the hydrographic map I saw a number of circular cirques marked as having stagnant water. For a long time I was so occupied with hunting for caves that I paid no attention to these cirques, but after having found in a number of the caves veritable kitchenmiddens consisting almost exclusively of a gastropod, the habitat of which I could not discover, I was finally led to search for it in the cirques themselves, and this — a failure as far as the cave-shell was concerned — opened up a new chapter in the understanding of the Baie d'Along erosion.

My search began with l'Ile des Deux Cirques (fig. 53 and Pl. XL), W. of the northern part of l'Ile de la Surprise. Through a narrow entrance (Pl. XL A), so shallow that we could hardly pass in at low tide, we entered into a small circular bay. Having crossed this first circular bay we had to climb a ridge, 15—20 metres high, (Pl. XL A). From this ridge we looked down into a small, entirely landlocked water circular in shape and about 100 metres in diameter, framed in by

high steep limestone walls. It contained salt water, had a narrow and thin fringe of mangroves (Pl. XL B) and contained an impoverished marine fauna. At the extreme east we could guess where the communication with the open sea was to be found, but the channel was so narrow that no light came through.

My next experience with cirques was upon l'Ile de l'Union (fig. 54 : 1). This cirque is located on the east side of the island. Having climbed a steep limestone threshold 15 metres high, we come across a large cirque somewhat oval in shape with a larger diameter of about 300 metres. In the southeast there is another pass, probably only 10 metres high. But for the rest the limestone walls rise often perpendicularly to quite 100 metres. No passage to the sea is visible, but the fauna is purely marine, the tidal rocks being entirely encrusted with small oysters. The horizontal erosion cutting is very strongly developed, with the subzone c in a singularly elevated position and strongly undercut upon one of the vertical cliffs (Pl. XXXVIII A).

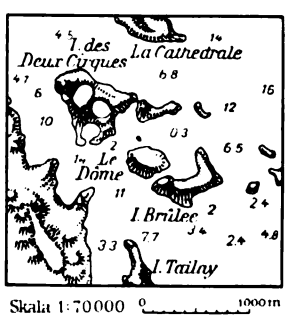

Fig. 53. Ile des Deux Cirques. (From the French Admiralty chart.)

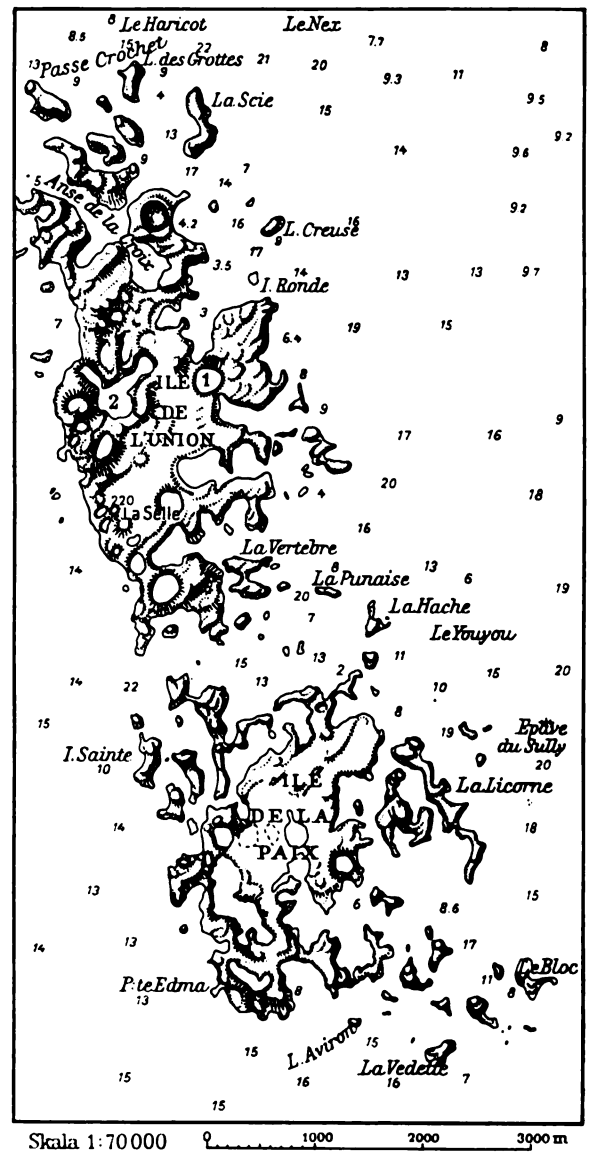

Fig. 54. Part of the French (1 : 70 000) Admiralty chart showing at the top the small Ile de Grottes and in the centre the large Ile de l'Union with the Anse de la Croix and various cirques.

The most interesting of the cirques which I studied were those on the west side of l'Ile de l'Union (fig. 54:2). Here we climbed a steep threshold, 10 metres high, without any trace of a path, so that we had to cut our way through with knives. But when we arrived at the top of the low ridge we faced a vast inland water about one kilometre across in each direction (Pl. XXXIX A). To our immense surprise we saw a sampan with some men, who offered us their services. They told us that they used to come in through a low but broad vault close by the threshold we had passed. They had to enter at low tide and stay until the tide had fallen again as the channel at high tide was quite impassable. The sampan brought us to the other end of this vast and rather irregularly contoured water. Here we reached another threshold 20 meters high with a well worn path, and from this barrier we looked down into a very small water, 100—200 m., and saw the surface largely covered with big patches of green algae giving the impression of a freshwater lake. But when we descended we found a peculiar dwarfed marine fauna: two small bivalves like Mytilus and Tellina, a small gastropod, a small prawn, a small Medusa, an Actinia, etc. Here was no sign of tidal changes of level, so it is evident that the seawater seeps through only with great difficulty.

When returning by sampan from this inner cirque we found that the water had fallen to such an extent that we could pass by the rock outlet from the outer cirque to the open sea. The passage was low, leaving only about a metre above our heads. I gauged it to be something like fifty metres long by fifteen wide. The tide was now running like a surging torrent, which swept us out of the cirque at a considerable speed. Later in the day I returned and entered the cirques for a second time. The tunnel was now relatively high so that we could take photographs (Pl. XXXIX B), and the current was slow with a small volume of water.

I have dwelt upon the cirques at some length because this study opened up for me new vistas for the explanation of the whole erosion problem and especially the formation of the caves.

As indicated by Patte in the above quotation, there is no doubt that the cirques, the small entirely landlocked waterbasins in the interior of the limestone islands, are one of the several features of a »karst» topography that implies a product of subaerial denudation produced by the leaching effect of water seeping down through sink holes at the bottom of the »dolines», to borrow another term from the karst terminology. All this topography was modelled out in its main features during a time when the whole limestone formation was resting above sea-level, as is the case with the Cat Ba island today. Now part of the limestone area is submerged under the surface of the sea, so that only the summits of the old karst landscape rise 100—200 metres above sea-level. Not only are these limestone rocks subjected all round to the erosive attack of the sea waves, but another powerful erosive agent, the tidal currents, has carried out its destructive action, less visibly but still relentlessly. The whole limestone formation is traversed by in-

numerable diaclases, through which the tide is being pumped in and out once every twentyfour hours. The fact that most of the cirques show the full effects of tidal rise and fall proves this beyond doubt. This ceaseless movement of the tidal waters increases the erosion in many ways. In the fully landlocked cirques you still have the characteristic undercutting in the tidal zone with its complement, the collapse from time to time of the undercut cliffs. Thanks originally to the cirque topography, the marine erosion now attacks the limestone islands not only from the outside but from the inside as well. In fact, many of these islands

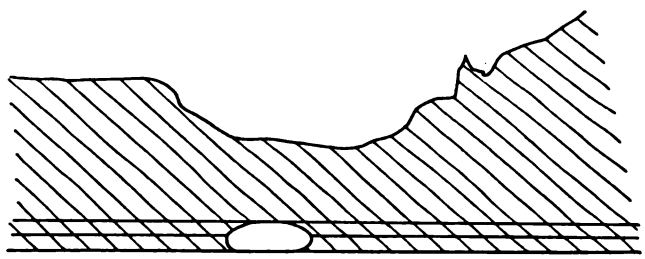

Fig. 55. Rock tunnel formed by marine undercutting.

are only thin shells hiding in their interior vast cirques (compare for instance figs. 53—54 borrowed from the hydrographic map). Only if we take into account this hidden internal erosion can we fully understand the strange and complicated contours of these islands.

From our own particular point of view the tunnels connecting the cirques with the open sea are of primary interest. Take for instance the tunnel just described in connection with the big cirque on the west side of l'Ile de l'Union (Pl. XXXIX B). Here we have a regular tunnel something like 50 metres long, 10—15 metres broad and some few metres high, evidently cut by the untiring erosion of the tidal stream here rushing in and out at considerable speed. Other similar tunnels, all due to tidal erosion and wave action, are shown in Pl. XLI and fig. 55. The tunnel of the big Ile de l'Union cirque has much in common with the big cave of l'Ile des Grottes (Pl. XLIII). They are both relatively low when compared with their other dimensions and have both the same smoothly rounded roof and entrance. I regret now that I did not examine the large cave of l'Ile des Grottes from this point of view. Certainly the innermost part of this cave must be quite near the other side of the small islet. If there had once been a tunnel straight through the island it may later on have become choked by stalagmite deposition. It must not be forgotten that, at the time when the marine erosion cut this chamber in its interior, the island must have been submerged something like five metres lower than it is now. Nowdays it is entirely withdrawn from direct marine influence, and the profuse stalagmite deposition may well have hidden part of its old features.

The old Caves.

In order fully to understand the very complicated processes, the combined action of which has produced this strange island world, it is necessary to know what I shall call the old caves. To understand the meaning of this term let us turn

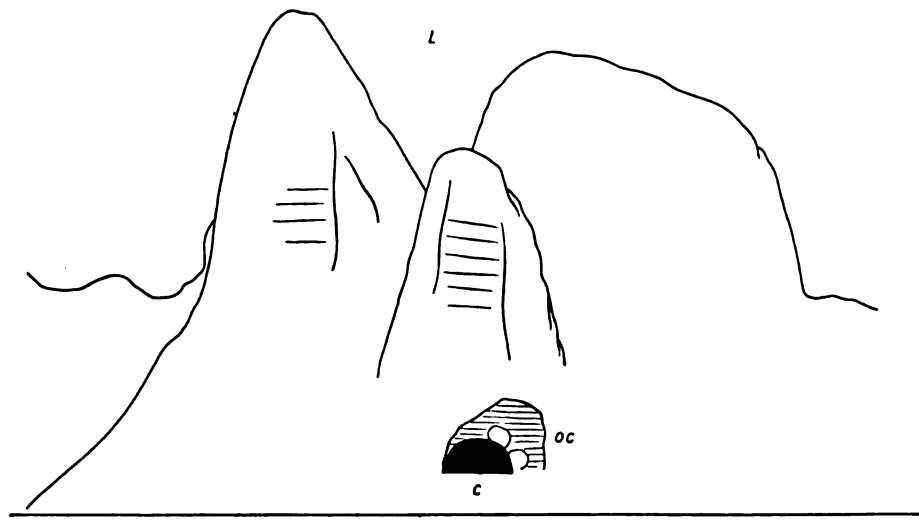

Fig. 56. Grotte des Sylphes.
L = limestone hills. c = modern cave. oc = old cave.

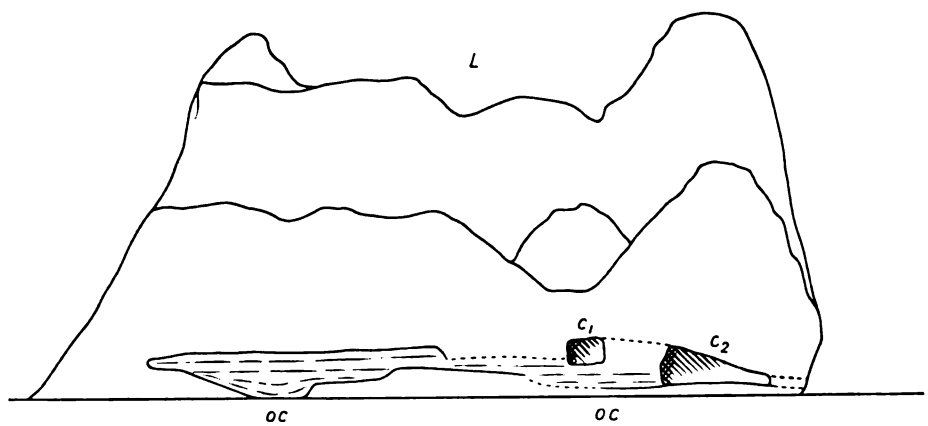

Fig. 57. Grotte des Coquilles.
L = Summits of the island. c_1—c_2 = modern cave. oc = old cave.

to the description of the Grotte des Sylphes (page 93—95). Here we have a typical equidimensional cave of relatively modest size. But already when we view it from the shallow water in front of the cave it becomes obvious that the cave was once considerably larger. The original chamber in the limestone was much higher

(see fig. 56) and it extended further to the west. These former extensions of the cave room are now filled with some kind of sediment exhibiting fairly regular horizontal bedding. When we reach the mouth of the cave, the true nature of this sediment becomes clear. It is a very hard, partly crystalline sediment of yellowish ochre colour. As it often contains angular fragments of the limestone and thus attains a brecciated structure, I have named it *Cave Breccia*. Unfortunately it is mostly barren of fossils and those sometimes found are only land

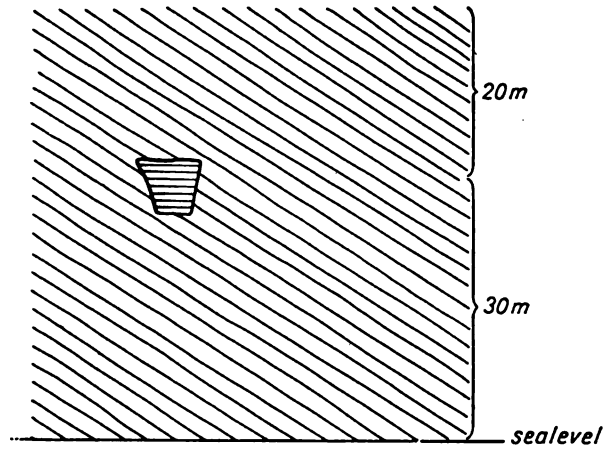

Fig. 58. Small cave in steeply dipping limestone. The cave filled with horizontally bedded breccia.

shells, so that the question of the age of the old caves and their breccia still remains unsolved. But there is no doubt that in the case of the Grotte des Sylphes the present small cave is only a reopening of an old, much larger cave room that was once entirely filled with the ochre-coloured breccia. We have already described how the breccia still forms the roof and the western wall of the modern cave. Moreover, the threshold of the cave consists of stratified hard breccia. Only in the eastern wall does the limestone frame in the modern cave.

If we now proceed to the Grotte des Coquilles in the Ile de Brandon group (Pl. XLV, XLVI and fig. 57) we shall find still further illustrations of the fact that here there are two widely different generations of caves. The modern cavern is quite a small chamber, but all along this side of the small islet we can distinctly trace the contour of a low horizontal cave now entirely filled up with distinctly stratified reddish-brown breccia. At one place in the southern part of the cave the sediment reaches down to and possibly slightly below sea-level. Granted that this old cave is also a product of marine erosion, it must have been formed at very much the present level of the sea. In the lowest part of the breccia were

collected some small shells. In another place we noticed an interbedded pocket of quite modern oyster sediment capped over by a stalagmite crust!

At the mouth of the large modern Grotte du Ciseau, Ile des Grottes, there is on either side a considerable deposit of the typical stratified hard ochre-coloured breccia, which also occurs near sea level all along in front of the cave mouth. Here very numerous and well-preserved land shells were collected in the breccia.

I also noticed in many other places within this archipelago small cave rooms filled with this ochre-coloured, horizontally stratified breccia. Specially interesting

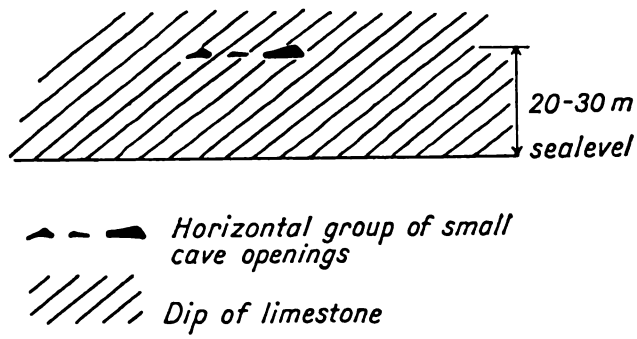

Fig. 59. Horizontal group of small cave openings in steeply dipping limestone.

are the finds of such old, filled-up cave rooms high above the present sea level. I had no time to try to reach any of these sections high up upon perpendicular walls, but have only sketched them when passing by, with a rough estimate of the heights. Newertheless, figures like 58—59 speak an unmistakable language. We see caves filled with horizontally bedded breccia 20—30 metres above the present sea-level. The significance of these observations will be touched upon in the following chapter.

Changes of level in the Fai Tsi Long Island world:

There can be no doubt that this limestone area once formed a continuous mass; in other words that an old peneplain, 300—400 metres above the present sea-level, is indicated by the Cat Ba massif and by the myriads of limestone islets. In the absence of recent sediment that could give a dating we are unable to tell anything about the age of this now so deeply dissected peneplain.

Similarly, it is out of question to tell anything about the age of the period following after the peneplanation, when this region had emerged higher above sea-level than it is nowadays. But it is evident that this was the case once. The depths as shown by the hydrographic map give us a strange picture of the bathymetric conditions. Practically everywhere the steep and precipitous limestone

islands, with a height of hundred metres or more, rise abruptly from depths of only a few metres. The submarine part of this archipelago is practically one extensive mudflat, large parts of which are actually laid bare at every low tide.

But in this exceedingly shallow sea there are a number of deep channels. Such a deep-water area is the outer part of Port Courbet, with 22 metres at the very mouth.

Further south, W of l'Ile de la Surprise, there is the Chenal du Volta, where — near Ile de l'Etoile, — we find a depth of 28 metres.

From the open sea the »Entrée Profonde» leads into the archipelago, and here we have W of l'Ile de l'Union 30 m., and near Le Crapaud, 31 m.

These deep channels are not continuous but there are shallows where you would expect them to be combined; still I have a very strong impression that these deep channels form the remnants of an old submerged and partly silted-over river system denoting that the area was once at least 30 metres higher than at present.

If we take all these facts into account we arrive at the following physiographic history of the Fai Tsi Long area: —

1. Faulting and folding of the limestone formation.
2. Peneplanation of the area at a time when the base of erosion was 300—400 m. above present sea-level.
3. Rise of the whole area and the cutting of river valleys down to 30 m below present sea-level. Dissection of the limestone plateau and development of a karst topography.
4. Minor changes of level up to 30 metres above present sea-level and cutting of *old caves* from 30 m. above down to present sea-level.
5. Filling-up of the old caves by deposition of stratified ochre-coloured breccia, locally with landshells.
6. Formation of *young caves* through partial removal of the breccia filling the old caves.
7. Continued marine erosion of the old karst features resulting in pillar-shaped islets.

DESCRIPTION OF THE CAVES

Cave upon the eastern islet of les Jumeaux:

Four kilometres E of Hongay lie in the midst of innumerable small limestone islands two twin rocks, Les Jumeaux.

Upon the eastern one of these I found on January 23 a cave which offered for the first time an opportunity of studying the remarkable »sédiment de la coquille des Grottes». As we later found much richer sites of this type only a short tentative excavation accompanied by some measurements was undertaken on February 16.

The mouth of the cave turns towards east to south.

Six metres above highwater level is the lowest part of the cave-mouth. The mouth is 25 metres wide, the height is estimated at 30 metres and the horizontal depth at 20 metres.

Between 7.5—9 metres above the sea there is abundant kitchen-midden sediment, which extends down the slope as far as to 3 metres above high water. Nine metres is the highest level for the loose earthy kitchen-midden soil, but as high as 15 m. above sea-level there were found patches of hard cemented shell sediment.

The whole slope up to the cave is steep, about 45°.

The shell sediment consists almost exclusively of a gastropod named by us »Coquille des Grottes» and a fairly large Helicid. But in addition we found a few marine mussels.

In the shell sediment we excavated numerous bone fragments, nearly all burnt black. Further finds were a fine shovelshaped stone axe and a coarse stone axe.

Grotte de La Selle:

La Selle is a medium-sized island SE from l'Ile des Merveilles. On the east side of this island there is a small cave about 8 m. above sea-level. It is about 15 metres broad at the mouth, 15 m. deep reckoned horizontally and 6 m. high.

The sediment is mostly red barren soil, but in one small spot there was some shell-sediment and in this was found a strange association of a big stone axe, some cash, probably less than a hundred years old, and a ring of greenish jade, probably also not very old.

Grotte du Crucifié:

L'Ile du Crucifié is situated in the northeastern part of the archipelago, SW from l'Ile Madeleine. Here we found about 8 m. above sea-level, a small cave with abundant consolidated shell-sediment.

In the open, by the side of the cave, an accumulation of loose unconsolidated shell-sediment, in which we dug to a depth of 1.2 m. without finding anything but some charred bones.

Grotte des Huitres:

La Poire is a medium-sized limestone island at the western end of l'Ile Rousse. Here are several caves, one of which proved of some interest to us. This cave is very irregular, something half way between cave and rockshelter. Access to it is very difficult, over huge chaotic limestone blocks piled up to the height of 9 m. The length of the cave is 15 metres in the direction E 20° S — W 20° N, which is nearly parallel to the shore. The height of the cave-floor above sea-level is

6 metres, sloping down to only 1.5 m. Farthest in there is a very narrow small room, in which was found a large deposit of huge (15 cm) oyster shells. From this find the cave was named *Grotte des Huitres.*

Both loose and consolidated shell-sediment. Here it was particularly evident that the hard cemented sediment occurs for the most part close by the cave walls and that these parts of the sediment are covered with stalagmite crusts sometimes as thick as ten cm.

Here we found only a fragment of a stone axe and a piece of pottery.

Grotte des Coquilles:

This cave (Pl. XLV, XLVI and fig. 57) is located upon a very small islet in the eastern part of the Brandon group. The exact position can be marked on the hydrographic map as being E from the figure 16 south from Ile Bichot.

The mouth of the cave faces due E. The floor is 6 m. above sea-level. The cave is very small, 6.5 m broad, and the horizontal depth is also 6.5 m, the height 5 m. To the north it is connected with a sloping passage leading down to sea-level. In the usual shell-sediment, consisting predominantly of the »Coquille des Grottes», were here found several species of large marine molluscs, and the cave was therefore called *Grotte des Coquilles.* No artifacts were found in this cave.

The islet upon which this cave is located is of great interest in so far that we can here prove better than elsewhere (see fig. 57 and panorama Pl. XLVI) that the modern caves are in many instances merely revivals of old caves now largely filled with cave breccia. For nearly the whole length of the island we can trace a low, horizontal cave of much the same shape and size as the »Grotte du Ciseau» described below. Only in the northern part has the old cave sediment been removed in two places, the small cave and the sloping passage, for the rest the cave breccia still fills the whole space of the ancient cavern.

Grotte des Sylphes (Map 5).

This cave is situated on the east side of Port des Sylphes in a little cove running south-eastward to the village of Tra Ban. The cove and also the adjacent part of the port are very shallow, making the approach somewhat difficult at low tide.

On the south side of the cove there rise three steep and high limestone domes (see fig. 56) and in the middle and smallest one of them the cave is located. As shown in fig. 56, drawn from the opposite side of the cove, the present-day cave is only a partial reopening of an old cave, still entirely filled in the upper and western part with breccia (Pl. XLVII).

The cave mouth faces northeast, but the longitudinal axis of the cave is due N—S.

From the beach, built up of highly corroded limestone cliffs, there rises a slope

up to the cave mouth at an altitude of 13 m. above high-tide level, but on this slope there are two terraces, the lower one being small and less conspicuous. The upper terrace is indicated on the map by the excavation rectangle 9.2—8.7, which forms a broad trench across it. The soil of less than a metre in depth is a red tough clay with sparse cave shells. As no old objects were found here this terrace may have been formed in relatively recent time (possibly when the cave was emptied of its shell content?).

The cave mouth has a level shelf at a height of 13 metres. The shelf is formed by a thin layer of red earth resting upon a bed of stratified cave breccia.

On the slope in front of the cave down towards the sea there are numerous outcrops of the limestone, indicating that probably the breccia-shelf at the cave mouth does not reach very far down. At its entrance the cave is ten metres high and in the interior the height of the roof is the same, but the relative height of the inner part of the cave is considerably (about 6 m.) larger than at the mouth because the floor of the inner part is so much less above sea-level. The mouth is 13 m. above sea-level, whereas the inner part of the big chamber has its floor only 7—5 m. above the sea.

There are two rooms projecting into the inner wall of the cave, one — probably a very short one — high up to the east and another very low down, facing south. This low-lying room represents by far the lowest part of the cave, its innermost, very narrow part having its bottom only about 2 m. above sea level. In the big cave room there are shown on the map two big blocks, between which the passage leading to this low-lying narrow room descends, the contour of the chamber being indicated by a line of strokes.

As already stated above, on the upper terrace in front of the cave there is some red earth with sparse shells of the cave types. We found nothing whatsoever here and the terrace may have been formed relatively recently. In the cave there is only a comparatively small quantity of loose, unconsolidated shell sediment. Some is found at figure 7 at the bottom of the main chamber, and near this spot the only stone axe of this cave was found in the loose shell-sediment. Another small body of this unconsolidated sediment was noticed in the narrow southern room.

The outstanding feature of this cave is the consolidated shell-sediment, which here occurs more abundantly and under more illuminative conditions than in any other of these caves. It is only on the west side of the cave that this sediment occurs, but here it forms an almost continuous sloping shelf for a distance of 28 m. all the way from figure 15.1 to fig. 4.1.

It is very easy to see from the longitudinal diagram on the map how the consolidated sediment slopes fairly uniformly from 15,2 m. at the cave mouth all the way along the wall of the big room and from there into the narrow southern passage, where it reaches its lowest point, 4,1 m., only two metres above the lowest point of the floor of this passage. This steep incline of the shell sediment

from the entrance inwards may — so far as I am able to judge — be explained only in one way. The people who once inhabited the cave lived at the very mouth, where they peeled the animals out of the mollusc shells, and the shells together with other refuse were allowed to drop in one of two ways, either outwards over the slope towards the sea shore or else inwards, forming a sloping surface which has been preserved along the western wall thanks to abundant stalagmite flowing over the shell sediment.

The transverse section along the line P—P on the map shows how the consolidated sediment forms merely a thin shelf pasted to the steep cave wall. Undoubtedly the accumulation of shells must once have filled the lower part of the chamber as indicated by the dotted line. How this huge volume of probably entirely unconsolidated shell sediment has been carried away by man or dissolved by water is a riddle that baffles me.

Only in this cave did we undertake systematic collecting in the hard, well-cemented shell conglomerate. The sloping shelf was divided into four parts, each of which was systematically worked by one man Pl. XLVIII. In this way we succeeded in extracting from this hardened sediment quite a number of the same kind of objects as found in the unconsolidated sediment, bones, mostly charred, horn and bone implements, worked stones and some few traces of pottery.

Grotte du Ciseau (Map 4).

North of Ile de l'Union there is a small islet named l'Ile des Grottes (fig. 60). One of the Grottes is a rather irregular cave within the tides, whereas the other (Pl. XLIII, XLIV) is one of the largest and finest caves within the whole archipelago.

Map 4 shows it surveyed upon the scale 1 : 500 and here reduced to 1 : 1 000. The threshold at the cave mouth is at a height of 2.8—4.4 m. above sea-level. From the entrance the floor slopes down gently inwards until near the central stalagmite pillars the height above sea-level is only one metre, and this height is maintained all the way through the inner part of the cave, where the floor is quite level. All the heights given in the map are reckoned from the highest trace of wave erosion upon the coastal cliffs, which is regarded being approximately the high-tide mark. Consequently the level floor of the cave, consisting of red earth and stalagmite deposit, is at a height of one metre above the high-tide level.

We have already mentioned that the threshold is 3 metres higher than the floor in the interior. This is due mainly to the accumulation at the mouth of large angular limestone blocks that have evidently fallen down from the cliff above. But in addition the whole outward, well lighted part of the cave is covered with the same unconsolidated shell sediment as we have already described from the other caves. This cave is unique, in that here we found no trace of the hard

cemented shell-sediment which forms such a conspicuous feature along the walls of some of the other caves, especially La Grotte des Sylphes.

The shell-deposit which fills the whole front, light part of the cave to the central stalagmite pillars is by far the largest such deposit so far known in these islands. It has a length parallel to the cave mouth of 45 m. and a width of 28 m. The thickness of this deposit is largest at the cave mouth, where we encountered in the big trench as much as 1.8 m. of shell sediment much mixed with big limestone blocks. Further inside the cave the thickness was much less, 0.8—0.6 m., down to 0.2

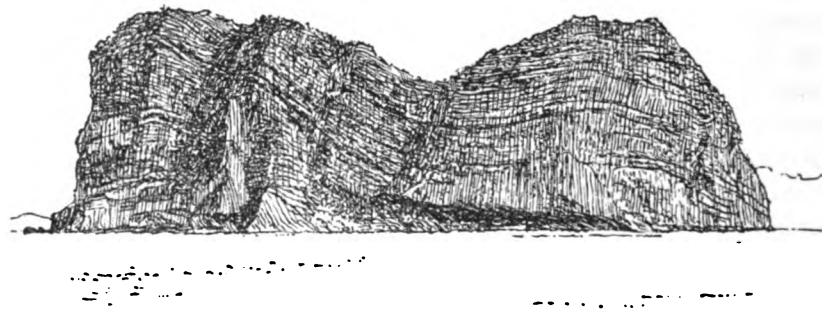

Fig. 60. Ile des Grotte with the mouth of La Grotte du Ciseau.

and 0.1 m. furtherst in, where the deposit dwindles down to nothing. What we noticed in the other caves applies also here, that the cave shell-sediment is most abundant at the entrance, which was apparently the favourite spot used by the shell-eating cave dwellers.

Within the shall-deposit area there are not less than ten depressions or pits, more or less circular and with gentle slopes. These pits are rarely as deep as a whole metre, but mostly the depth is more than half a metre. Two explanations might be suggested. One is that each pit marks a hearth, the old cave-dwellers' centre for cooking and eating. This was my first explanation. But as we found in the big trench, even at a considerable depth and far inside the cave, such apparently modern things as a broken armlet of glass paste (?) and a probably false diamond, I was forced to another much more profane explanation, namely that the pits were made by treasure-seekers, who worked in a haphazard way and allowed their womenfolk's finery to fall and become lost amongst the old deposit.

The content of the shell deposit is predominantly made up of the gastropod which during the field work I named »La Coquille des Grottes», and which later on *mirabile dictu* we found to be a freshwater shell; it has subsequently been identified by Melle Colani as a species of *Melania*. Next in volume come two landshells of the Helix type, one smaller and one of a large size. But there are also in this deposit shells from the sea, as for instance the large oysters which

we also came across in other caves, and numerous other species. But the sea shells are always very scarce and some gastropods which fill the shore even outside this cave and are eaten in large quantities by the island population of today are entirely absent in the shell deposit. Another quite important component of this cave sediment is mammal bones, apparently refuse from the meals of the old cave-dwellers, who seem to have had a far richer menu than the poor sampan people who now inhabit these shores.

So far we have paid no attention to the contours of this cave. As is most distinctly shown by the sections on the map, one across the entrance and the other from the mouth to the innermost part, this large cave is a typical representative of the group of caves termed horizontal. The mouth is 38 metres in width by 11.5 in height. The horizontal depth is not less than eighty metres with a height only one-eighth of that figure.

The modern Grotte du Ciseau is as typically a horizontal cave as is the old Grotte des Coquilles. Is, then, the Grotte du Ciseau also an old cave revived by removal of the breccia which once filled it? To answer that question let me first make a statement: there is absolutely no cave breccia preserved on the roof of the cave. Wherever the roof is not coated over with stalagmite there it is easy to see that everywhere the roof is formed of limestone. But there are two considerable spurs of typical cave breccia at both sides of the entrance. They are indicated on the map by a special contour, the one from the northeastern corner being long and slender, while the one from the southwestern corner is broad and triangular. But in addition there is a continuous outcrop of stratified breccia along the sea shore across the entire front of the entrance to the cave. This outcrop is best seen just above the high-water level, and it seems as if the island must have been raised slightly above its present level then this horizontally stratified breccia was formed, an observation that is further supported by the fact that this breccia is crowded with beautifully preserved land shells, Helicids and others. The actual rock floor of the cave is nowhere visible being everywhere hidden by shell-sediment, fallen blocks from the roof, red cave soil and stalagmites. The only surmise we can make, therefore, is that the cave breccia seen so extensively before the entrance may reach for some distance into the cave, which would indicate that this large and beautiful cave is another old cave revived by erosion.

OPEN AIR SITES

The Danh Do La Site (Map 6):

The Danh Do La site is situated nearly in the centre of Danh Do La island, south of a low mountain spur about 40—50 m. in height. To the NW there is a shallow creek, which once divided the western part of the island from the main eastern part. About a kilometre south from the site there is a vast sandy beach

facing the open sea, and some distance E of the site another almost dried up creek runs up northwards from the eastern corner of the long beach. The site is thus surrounded by the sea in three directions, W, S and E. Only to the north is there a low mountain spur immediately bordering on the site, and I believe that the combined factors of easy access to the sea in three directions ad then protection offered by the mountain give the clue to the assumption that just here there settled a colony of what I propose to name from this type locality *the Danh Do La people*. In order fully to realize the significance of this combination of topographic factors we may at once point to the probability that at the time of the Danh Do La culture the sea-level was something like 2 metres higher than it is now. Assuming that the sea was two metres above the present level, the waves of the ocean must have almost lapped the base of the low sandy reef upon which the old village was built. The northwestern creek, now accessible only at high tide, was then a good fishing ground. The thundering of the surf upon the southern beach was then heard much more distinctly than today and there may then have been reason to fear that a typhoon might make its way across the marshy sand flat south of the village. But the proximity to the steep hillslope gave the inhabitants a much-needed feeling of security. Moreover, the southeastern creek, nowadays not visited by sampans, may then have been a secure boat harbour and a fishing water.

In the introductory chapter on the reconnaissance we have already described how the discovery of this site was made on the 25th January, in fact it was the first find of a prehistoric site in the whole archipelago. As a result of enquiries made by M. Tran we collected from the village men five stone axes, but no information was forthcoming as to their provenance. It struck me that this central mountain spur was surrounded by the sea on three sides, so I went there to search. On the surface there were no indications whatsoever, but most fortunately an industrial enterprise came to our rescue. Upon these islands there occur over wide areas behind the sandy beaches vast expanses of low-lying land where under the dense bush a perfectly white sand is found consisting almost exclusively of quartz. This sand is in great demand for glass factories, and a Haiphong man, M. Vu Xuan Tao, had here opened up a quarry connected with the northwestern creek by a light railway. Where the railway crosses the slight elevation formed by the accumulation of the ancient village there is a cut about two metres deep and reaching down to the white sand beneath the culture stratum. In this neat and clear cut I found thin and very brittle pottery of a type so far unknown, and it seemed highly probable that we had found here a prehistoric village site.

Some few days later, on the 28th of the same month, we returned to Danh Do La and spent the day in a small experimental excavation, which proved very encouraging. A report on the find was made to M. Coedes, the Director of the Ecole Française d'Extrême Orient, who at my request wrote to M. Vu Xuan Tao, the owner of the sand quarry. It took us a long time to complete the reconnaissance

of the archipelago and explore the caves, so that it was not until the 12th March that we again reached Danh Do La island. Just before our departure for regular excavation work at Danh Do La, M. Lapicque's reconnaissance at Port Courbet brought to light a most promising site at Dong Mau. Consequently we found it advisable to shorten our stay at Danh Do La. Our sojourn there up to the 19th March was sufficient to allow me to survey the site very carefully on the scale 1 : 1 000 (here reduced to 1 : 1 500). But our regular excavation of a small area in the easternmost corner of the site was barely sufficient fully to prove the existence here of a rich site of a type so far unknown.

Map 6 shows the site and its immediate surroundings on the scale 1 : 1 500. The zero point for the height figures and the contour lines is the highest level to which the living mangrove reaches in the corner of the mangrove-covered mudflat shown to the extreme left of the map. It is assumed here, as in all the other surveys made by me in this area, that the upper limit of the mangrove growth approximately coincides with the high tide level.

The contour lines 1—10 in the upper part of the map indicate the lowest part of the mountain spur, which was estimated to be 40—50 m. high. To the south of this hill and east of the paddy field there is a broad expanse of white sand, in fact extending southwards for several hundred metres, running the whole way out to join the modern sandy beach. It is in the NE part of this sandflat, about 4 m. above sea-level, that the pure quartz sand has been found, and it is here to the east of the prehistoric site that the sand is quarried and transported by the light truckway down to the northwestern creek shown very clearly in the panorama Pl. XLIX A. (In studying the two panoramas it should be noted that the northwest creek is connected by a narrow passage with the westernmost corner of the long southern beach. Consequently the wooded sandflat behind the houses, panorama Pl. XLIX B, is not directly connected with the southwestern hill range of the island, as might be supposed from the panorama.)

It is in the corner formed by the 40-metre hill, the paddy field and the 4-metre sandflat that the site is located, overlapping a small part of the sandflat and taking shelter at the foot of the hill.

The extent and shape of the site was established by aid of a number of experimental diggings, shown on the map. Those along the southern contour of the site and marked (from E to W) by the height figures 4.2, 4.2, 4.1, 4.5 and 4.8 have a minus mark indicating that no sign of culture earth was detected there. The inside test pits along the south contour, 5.0, 5.25, 5.3, 5.4, 5.3 and 5.1 have a plus cross mark indicating that in all these pits the culture stratum was struck.

It will be seen from the map that the main body of the site is found under a surface 4 to 5.5 metres above highwater level. If we assume that the average height of the sandflat is four metres, then it becomes apparent that the additional height of the site is due to the culture deposit and to the barren sand covering the culture stratum. Only a very small corner of the site at the base of the hill

rises to or slightly above the 6-metre curve. On the other hand, at the western end of the railroad cut, at the place marked by the figures 3.4 and 2.7, there are indications of in situ pottery as low down as 2.7 metres. It is possible that these in situ pottery finds mark only washouts or droppings by prehistoric man, but the conditions were such as to suggest the idea that the seashore had been near this spot when the site was formed. Under no circumstances could the sea-level have been as high as 3.4 above the present level because here we had a regular culture stratum like the rest of the site. The mode of deposit of the pottery sherds found at 2.7 is more doubtful. My personal surmise, based on all too slender evidence, is that the sea-level at the formation of the site may have been about two metres higher than it is now. It could not have been higher than 2 m., as is shown by the findings at the 2.7—3.4 point; on the other hand, it seems probable that it was about 2 m. higher than the present sea surface as this rise of the sea level would have turned the surrounding creeks into good fishing grounds.

As seen from the map, the length of the site is 150 metres with a maximum width of 45 metres and an area of approximately 4 500 square metres. The square systematically excavated in the easternmost parts of the site, being only 50 square metres, amounts to sligthly more than one percent of the entire site.

In four places stratigraphical measurements were taken as given below; all sections counted from the bottom upwards.

1: In the test pit marked 5.3, due south of B 1: —

a. White sand ..... 0.7 m.
b. Transition zone, yellow sand ..... 0.2 m.
c. Culture stratum, slightly blackened sand ..... 0.4 m.
d. Surface sand ..... 0.3 m.

2: Between 91—92 in the excavation area (M. Tran's special plan): —

a. Yellowish white sand (stray finds made also in this stratum) .... 0.65 m.
b. Transition layer, chocolate-coloured sand with potsherds ..... 0.30 m.
c. Culture-stratum, dark-coloured sand, rich in potsherds, stones and uppermost a narrow layer full of pieces of pumice ..... 0.45 m.
d. Covering layer, slightly darkened sand ..... 0.60 m.
e. Greyish-brown sand, recently brought there..... 0.20 m.

3: 20 in the excavation plan: —

a. Brownish yellow sand..... 0.10 m.
aa. Whitish yellow sand ..... 0.40 m.
b. Light chocolate-coloured transition sand..... 0.45 m.
c. Culture-stratum, brownish sand, here relatively poor in finds 0.50 m.
d. Grey brownish surface sand ..... 0.45 m.

4: 6 metres north from the midst of the base-line B1-B2: —

a. White, slightly yellowish sand ..... 1.2 m.
b. Transition layer, yellowish sand ..... 0.4 m.
c. Culture-stratum, greybrown sand with potsherds, stones and pieces of pumice ..... 0.44 m.
d. Grey-brown surface sand ..... 0.45 m.

I should like here to call special attention to the finding of a real layer of pumice pieces in the uppermost part of the culture stratum of section 2 and of numerous pumice pieces in the culture stratum of section 4. Still more marked was a thin but densely packed layer of pumice pieces in the test pit 4.5 (»Pum.») just outside the boundary line of the site. This frequency of pumice in a defined layer contemporaneous with the prehistoric village may one day assume great significance. First, the frequent occurrence of pumice strongly supports my idea that the sea-surface was two metres higher than at present. Pumice is today thrown up in quantity upon the freely exposed southern beach and blown slightly inland some metres above sea-level. But floating pumice could not reach the site with the present sea-level, whereas a rise of two metres would open up the creeks in such a way that pumice would be washed ashore all over these beaches.

A much more far-fetched but far more fascinating possibility could one day be attached to these finds. Granted first that the Danh Do La site pumice proved different from the kind that is washed ashore today and granted further that the archaeologists and geologists of the Dutch East Indies, whence the pumice is most likely to have come, could determine the age of the eruption of that type of pumice, then there would arise the possibility of a dating of the Danh Do La site by ranging it with the volcanic chronology of Insulinde.

The Dong Mau Site (Map 7).

Our indefatigable friend and supporter in all the Baie D'Along and Fai Tsi Long research, M. P. A. Lapicque, undertook in the early part of March to make investigations, through his native workmen, into the question of any stone axes that may occur in the environs of Port Courbet. On the 6th of that month a stone axe was offered to him with the information that it had been found at Dong Mau, close by the western part of Port Courbet. Later two more objects of the same type were offered to M. Lapicque, who personally visited the place. On the 12th of the same month he took me there. Several more stone axes were found under our eyes by the local men, and I myself discovered in the maize-field some small pieces of the same type of pottery that we knew so well from Danh Do La.

We were at this very moment prepared for an extensive excavation campaign at Danh Do La, but the clear evidence here produced by M. Lapicque of another rich site of the same type made me at once change my plans to the extent that the Danh Do La excavation was to be shortened to about a week in order to

give sufficient time for a similar excavation period at the new and highly promising site of Dong Mau.

On the 19th March we returned from Danh Do La to Vachai late in the evening, and the following day, being a Sunday, was devoted to preparations for the coming exavation campaign in the Port Courbet region. In the afternoon M. Tran went with two sampans and our workmen to Dong Mau, taking advantage of the inflowing rising tide. On the following morning, the 21st, M. Lapicque and I went by car to Dong Mau and found awaiting us there M. Tran and the workmen, who had already made quite a number of surface finds, definitely confirming our surmise that here was an important site. As the finds were all made in an already planted maize-field it needed some arrangement with the farmers to be able to excavate here, and an agreement was soon come to thanks to the tactful mediation of M. Lapicque.

Under the supervision of M. Tran regular excavations were carried out in this site from the 21st to the 31st March and a rich collection of furniture, the most important of all the sites, was brought together. On the 26th of March I surveyed the sketch-map which is here reproduced as Map 7.

To the south of the site a low hill rises to 15—20 metres above sea-level. The lower parts of this hill are cultivated, the higher are covered with the usual brushwood. Upon the hilly ground there are two houses, one to the south, the other to the west of the site. Two hundred metres north of the site there rises another small circular hill with some houses and brushwood on the top. Between these two hills, the one to the south and the one to the north of the site, there extends a narrow, low isthmus bordering in an easterly direction on a mangrove-covered mud-flat and in the west on low, now cultivated fields, which rise very slightly above sea-level and must certainly have formed a mangrove flat in a not very distant past.

The site is located on the southern part of this isthmus, were it rises to meet the southern hill. The northernmost of our test pits E1 proved entirely barren, and in the next low pits E4—E7 only a few potsherds were noticed, possibly washed down from the neighbouring rich site.

The site itself occupies the northern and lowest part of a spur, rectangular in shape, which comes down from the southern hill and which is shown very clearly in outline on the map. Here in the test pits E8—E11 as well as in the three excavation pits F1—F3 a rich culture deposit was struck. Details of the stratigraphical conditions are given below, all measurements reckoned from the bottom upwards:

E1 : —

a. Yellow sand and gravel ..... 0.60 m.
b. Dark-coloured surface layer, sand and gravel. No finds 0.25 m.

E3: —

a. Hard packed yellow gravel ..... 0.10 m.
b. Barren brown sand..... 0.30 m.
c. Brown soil with pottery and stones, among them impure hematite ..... 0.38 m.

E4—E7: — In the bottom yellow hard sandy gravel. Dark surface layer, only here some potsherds.

E8: —

a. Fine sand, below yellow, uppermost brown, barren .. 0.25 m.
b. Brownish grey culture stratum ..... 0.57 m.
c. Brownish grey surface sand, few finds..... 0.30 m.

E10: —

a. Yellowish sand ..... 0.15 m.
b. Brownish grey culture stratum ..... 0.65 m.

E11: — Yellow barren sand.

In the northern big excavation (F1) above the basal sand, a brown culture stratum 0.75 m. thick.

The middle big excavation rectangle (F2): —

a. Hard packed yellow sand ..... 0.25 m.
b. Dark brownish grey culture soil..... 0.58 m.

Southern small excavation (F3): —

a. Hard reddish yellow sand ..... 0.25 m.
b. Dark culture stratum, poor ..... 0.41 m.
c. Brownish grey surface sand..... 0.36 m.

For the guidance of future visitors to this site who arrive overland from Haiphong or Hanoi it should be pointed out that it is most convenient to leave the Colonial Road just before passing from the mainland to l'Ile au Buisson. A small path, about a kilometre and a half in length, runs from there over two low hills due north to the Dong Mau site.

The Xich Tho Site (Map 8).

The singularly successful prospecting work undertaken by M. Lapicque resulted in the discovery of another site within the Port Courbet area. On the northern shore of Port Courbet, at a place named Xich Tho, his prospecting agents had gathered some stone axes and pieces of the well-characterized Danh Do La culture pottery.

On the 21st March, after having organized the Dong Mau excavation with the able help of M. Lapicque, I started together with Miss Dorf, my servant Chuang and two of M. Lapicque's men for Xich Tho. Borne along in our sampans by

the inflowing rising tide, we soon crossed the outer deepwater part of the port near its mouth and then went on over shallow expanses of water, finally entering into a narrow tidal channel, Sông Mân, bordered by immense flats of dense mangrove growth. To the right of this channel there rose a densely wooded promontory Go Miĕn, a real forest grove of magnificent trees and harbouring among the trees a small temple, as we got to know later. Half a kilometre further east there rose a larger, mostly barren hill, on which, as I found out the following day, stood an old walled-in fortification named Thanh Mac.

It was already growing dark when we reached the landing place, but a rapid visit to the spot indicated convinced us that here was a third site of the Danh Do La culture. A systematic search over the fields on the following day gave a harvest of a score of stone axes and a large number of grooved stones. And in the test pits, L 1 and L 2, we found in abundance the furniture of the said culture. As I had no assistant to carry out systematic excavations for a lengthy period I left already on the 25th in order to return to survey the more important Dong Mau site, where in the meantime M. Tran was conducting regular large-scale excavations. I surveyed the whole Xich Tho area on the scale 1 : 10 000 (reduced to 1 : 15 000) in order to illustrate the interesting topographical setting. But the extent of the culture deposit is indicated only approximately on the map, and the value of the site as a source of prehistoric artifacts is only partially surveyed. So far as we know now, the interest centres around loc. 1, where we came across 0.65-metre culture soil covered with barren sand. But other rich places may be found; in particular, the forestclad temple hill, which was not at all touched by us.

The dominating topographical feature of this area is the hill Thanh Mac, with its defence wall and the two gates, one to the south, the other to the north. The highest point, 38 metres, is at the north gate. The Thanh Mac hill is connected with the Go Miĕn temple hill by a flat, but distinctly marked isthmus which is cultivated all over. It is upon this isthmus that we found the site, and our survey coupled with those of Danh Do La and Dong Mau distinguish the people of this culture as being very markedly *Isthmus Dwellers.*

In all the four quarters of the compass the Xich Tho site is surrounded by extensive mangrove flats. Only to the east and further away to the NE is there continuous firm ground past the dominating Thanh Mac hill, but this promontory is bordered on both sides by mangrove fields and open water. If at the time of the prehistoric village the sea-level were two metres higher than it is now — and several observations point to that conclusion, here as at Danh Do La and Dong Mau — then the prehistoric dwellers certainly had open water and good fishing grounds both to the west, the south and the north of the narrow isthmus upon which they had chosen their home.

Loc. 2 proved of minor importance as the culture stratum is of shallow depth with no covering surface soil.

At loc. 1 Chuang made a big test pit, which yielded numerous and valuable finds. Here I measured the following section, counting from base to top: —

a. Light yellow gravel and sand ..... 0.20 m.
b. Dark brown sandy culture stratum..... 0.65 m.
c. Surface sand, of same colour as b but without artifacts..... 0.20 m.

Some general features of the sites: —

The description here given of prehistoric sites in the Fai Tsi Long — Port Courbet area is only topographical. The age of these cultures and their ethnological affinities can be discussed only after a complete examination of the extensive collections, research work which has been kindly undertaken by Melle Colani. However, there are a number of observations besides the topographical features which forced themselves upon my notice during the field work and which may deserve to be recorded here.

First of all it is apparent that we have had to deal with two widely different types of sites, the *caves* and the *open-air sites*. To a certain extent the contrast between the two may be due to the different state of preservation of the furniture. In the limestone caves there are numerous implements of bone and horn in the shell deposit and also an enormous number of broken mammal bones, evidently refuse from the meals of the ancient cave dwellers. On the other hand, in the Danh Do La open-air sites neither a broken bone, nor an instrument of bone or horn was ever discovered, and this must certainly be due to the leaching away of all bone and horn substances in the sand of the open-air site sediments, which are at once exceedingly poor in lime and easily penetrable by water. Here we have to deal with a difference between the two types of sites that is beyond doubt entirely secondary.

But a difference that is clearly of a primary nature is the scantiness of ceramic fragments in the cave kitchen-middens compared with the immense volume of potsherds in the open air sites. The shells which seem to have formed the main bulk of the cave dwellers' menu may have been eaten raw, but that could not have been the case with the mammals, which were eaten abundantly, to judge from the large number of mammal bones contained in the kitchen-middens. An interesting feature is that the larger part of the bones are blackened, presumably by fire. Is it possible that the cave dwellers roasted their game and in that way made themselves independent of cooking pots?

The scarcity of pottery in the cave deposits is such that I doubt whether it will be possible to compare chronologically and ethnically the cave culture with that of the Danh Do La sites. The stone implements are often rather obsolete when it comes to making comparisons of that kind, and bone or horn implements, probably once present in the open air sites, disappeared long ago thanks to leaching.

The main interest attaching to the cave deposits is undoubtedly their shell content, which is of a mysterious composition. I did not find time to make statistical

estimates of the relative frequency of the various species of shells in these kitchen middens, but I surmise that the composition is something like 90 % Melania, 9 % Helicids of two species, one medium sized and one very large; the remaining one percent is marine shells, very big oysters and other marine bivalves, but very rarely marine gastropods.

When I came as a stranger to these islands and discovered the shell accumulations in the caves it was natural that I should imagine the »Coquille des Grottes» to be a marine species. But I sought in vain for it on the beaches of the limestone islets. I made inquiries of the fishermen but nobody in these islands seemed to know this mysterious shell. Nobody had collected it and nobody had eaten it. I went into the more or less landlocked cirques and sought there for our evasive shell, but all in vain. Finally we found it living in a couple of streams upon l'Ile de la Table, and here we met another of the contradictions in the folklore of this shell. We shall return to this problem presently.

For some considerable time during the field work I held the view that this shell was collected not for food but for some forgotten industrial use, something in line with the purple industry. The mammal bones are in fact so frequent in the kitchen-middens that they could account for a good part of the food for the supposed industrial shell-gatherers.

But this theory collapsed when my learned friend Dr. Colani came to review the island caves and their shell content. She told me that this »Coquille des Grottes», *Melania* according to her communication, was common, forming shell deposits in the interior of Tonkin and that furthermore this same Melania occurs frequently in the inland streams and is commonly eaten by the people living along these streams. After our archaeological field work was completed and we were about to leave the Port Courbet region, I found an opportunity on the 3rd April of making an excursion in the company of Melle Paulette Lapicque and Miss Dorf, to the hills inside the northwestern part of Port Courbet. And here in a stream we collected a large number of the mystery shell. But not only that; we were told by the friendly local people that these shells are very frequently eaten, and they even went so far as to have a basket-full collected and boiled for our consumption!

Melle Colani's communication and my own subsequent observations have made me realize the utter futility of my shell industry theory. I am forced to submit to the belief that the Melanias out in the islands were also collected for food.

But let us now view the Melania problem from another point of departure, and we shall soon learn that the difficulties are far from being overcome.

The enormous accumulation of Melania shells in the big cave in l'Ile des Grottes is situated far from any stream where this freshwater shell could be procured. Probably the nearest source of supply is upon the big island Cat Ba. The old cave-dwellers must have gone quite a distance from their cave in order to procure a fresh supply of the treasured shell. On the other hand, between

high and low tide levels the very beach outside the cave is crowded with small oysters and a number of litoral gastropods, which are all eagerly collected and eaten by the present-day population. These small gastropods which are so commonly used as food today were never found by us in the kitchen-midden of the cave. There were collected something like fifteen species of marine mollusks, sparsely intermixed in the overwhelming volume of *Melania* and *Helix*. But these marine intermixtures in the ancient kitchen-midden are not of the common beach types, they are gigantic oysters never seen in the shell heaps of modern man, and other shells which form only an insignificant part of the shell food of the modern inhabitants of these islands.

Another of these anomalies connected with our shell problem. In the middle of l'Ile de la Table there is a village about three kilometres distant from Port des Sylphes and connected with that port by a small pathway. The women of the village often go down to Port des Sylphes and collect upon the shallow mud-flats laid bare at low tide these litoral shells, which fill the refuse heap at every house in the village. These same shells live in thousands below the Grotte des Sylphes, but not a single one of the small litoral gastropods was ever found in the consolidated kitchenmidden of the cave. On the other hand, every time these village women go down to the port and collect the litoral mollusks they cross two small streams where one can collect the living Melania among the river-pebbles. But this freshwater shell is never taken, and never is it found among the marine shells piled high at the houses in the village.

A nice cluster of riddles still awaiting a solution!

* * *

There is still another remark to be made about the open-air sites. In none of these deposits did we find fish bones; even in the cave kitchenmiddens, where the preservation of lime particles is so effective, no fish bones were noticed. Nevertheless I feel convinced that both these two cultures represent fish-eating peoples and that all traces of this part of their fare have disappeared owing to leaching.

In modern times most of the villages are agricultural and are consequently located in the interior of the islands some kilometres from the coast. The marked identity of the topographical setting of all the three Danh Do La sites as *isthmus villages* is comprehensible only if we assume that the inhabitants took most of their food from the sea. For agriculturalists the isthmus location would be entirely unsuitable.

But granted that the Danh Do La communities were fishing villages, this character of theirs forms a very strong argument in favour of my idea that at the time of these settlements the sea was two metres higher than now. In modern times the isthums location is somewhat obsolete owing to the drying-up of the surrounding land. A sea-level two metres higher would completely revive their old fishing-grounds.

TOPOGRAPHY OF THE HONGKONG SITES

Thanks to a number of Hongkong scientists, Dr. Heanley, Mr. Schofield and Professor Shellshear, but above all Father Finn, it was made known in the early half of this decade that on the Hongkong islands and the mainland there occurred sites containing a protohistoric culture, the rich and remarkable remains of which were made known through Father D. J. Finn's articles »Archaeological finds on Lamma Island near Hongkong» 1—13, published in the Hongkong Naturalist during the years 1932—36.

These communications, which abound in details about the objects found and in attempts to correlate them with other regions, give very little information as to the circumstances under which the finds were made.

The venerable and charming author of these notes, whose untimely death we all deeply regret, is in no way to be blamed for the lamentable lack of topographical data. On the contrary, it is only thanks to his zeal, devotion and persistence that the objects were saved from the hands of the sand-diggers and made known to the scientific world. In order to supply the ever-increasing building industry of the colony with sand native junkowners dug into the sandy beaches all along the Hongkong islands and in one of them, Lamma Island, close to the SW of the main island, these sanddiggers happened to strike the remains of a rich settlement presumably from the second half of the millenium before Christ. Their work was carried out in great haste, and it was no easy task for the enthusiastic amateur collector to save intact the specimens of pottery, stone and bronze which were brought to light in great numbers but in an entirely unscientific way.

In the summer of 1936 Father Finn visited Stockholm and studied for a week in the Museum of Far Eastern Antiquities. I was then planning a journey to the Far East and we agreed that I was to stay some time in Hongkong for the purpose of assisting Father Finn in undertaking systematic excavations.

When I arrived in Hongkong at the end of November 1936 I was met by Mr. Schofield, who had taken a very active part in the reconnaissance of the Hongkong sites. He brought me the very sad news of Father Finns premature and sudden death two weeks earlier in Ireland, but Mr. Schofield informed me at the same time that he was willing to enter into cooperation with me and that he had secured the interest and support of the Colonial Authorities for a reconnaissance and excavations within the Hongkong sites. After a visit to Shanghai and Nanking I returned to Hongkong on the 6th January 1937, this time accompanied by my secretary and photographer Miss V. C. Dorf and my veteran Chinese servant Chuang.

My cooperation with Schofield proved both pleasant and highly instructive. With remarkable pluck and accuracy this amateur archaeologist had acquired an extensive and reliable knowledge of the archaeological sites of the Colony, many of which were discovered by Mr. Schofield himself. It gives me great pleasure to record here my deep indebtedness to this gentleman, who in such a charming manner showed me round a great number of the archaeological sites.

After our joint reconnaissance was completed we agreed to undertake a regular excavation of a site, Shek Pek upon Lantau island, which was judged by Mr. Schofield to offer good prospects for rich finds. The excavation work was carried out by Mr Schofield and his assistants, I in the meantime undertaking a topographical survey of the site and its immediate surroundings (Map 9).

Shek Pek is a bay upon Lantau Island. A small stream flowing from a swampy area divides this bay into a southern part, the beach of which is strewn with huge boulders, and a northern part with a smooth sandy beach. It is behind this sandy beach 120 m. north of the stream that we found the archaeological site which is marked on the map in pink. The longitudinal axis of the site area is approximately 85 m. and its width is 30 m. at its very broadest. It will be seen from the map that the practically level area of the site is above the 6-metre contour line, no part of it reaching as high as 7 metres.

In the corner marked *excavation plan base* on the map a very small stream coming down from the mountain slope and carrying water only during the rains had washed away a part of the site. The sand and gravel left in the streambed was passed by us through screens and by this means very numerous objects of pottery, spearheads of slate, stone rings and some few small objects of bronze were found (Plate LV B).

When Mr. Schofield started regular excavations along »excavation plan base», taking exact measurements of horizontal and vertical coordinates for each object, he soon came across burials the skeletons of which were largely absorbed owing to leaching in this soil which is poor in lime. The very interesting furniture of these burials will be described by Mr. Schofield. I feel convinced that the systematic excavations carried out by him on a small scale at Shek Pek will mark a new period in handling the protohistoric monuments of the Hongkong Colony. After having witnessed the unearthing of regular burials at Shek Pek I have little doubt that the immense hoard of small bronzes and other delicate objects collected on Lamma Island under very difficult circumstances for the most part came from burials which had remained intact until the sanddiggers reached them. The leaching away of the skeletons may have obscured the fact that here were veritable sepulchres.

The Shek Pek excavation, small as it was, has done away with such tales as that the Hongkong litoral sites had been overturned by the typhoons. Here are still intact, coastal dwelling-sites including burials which are highly valuable to science and well deserving of the protection of the authorities.

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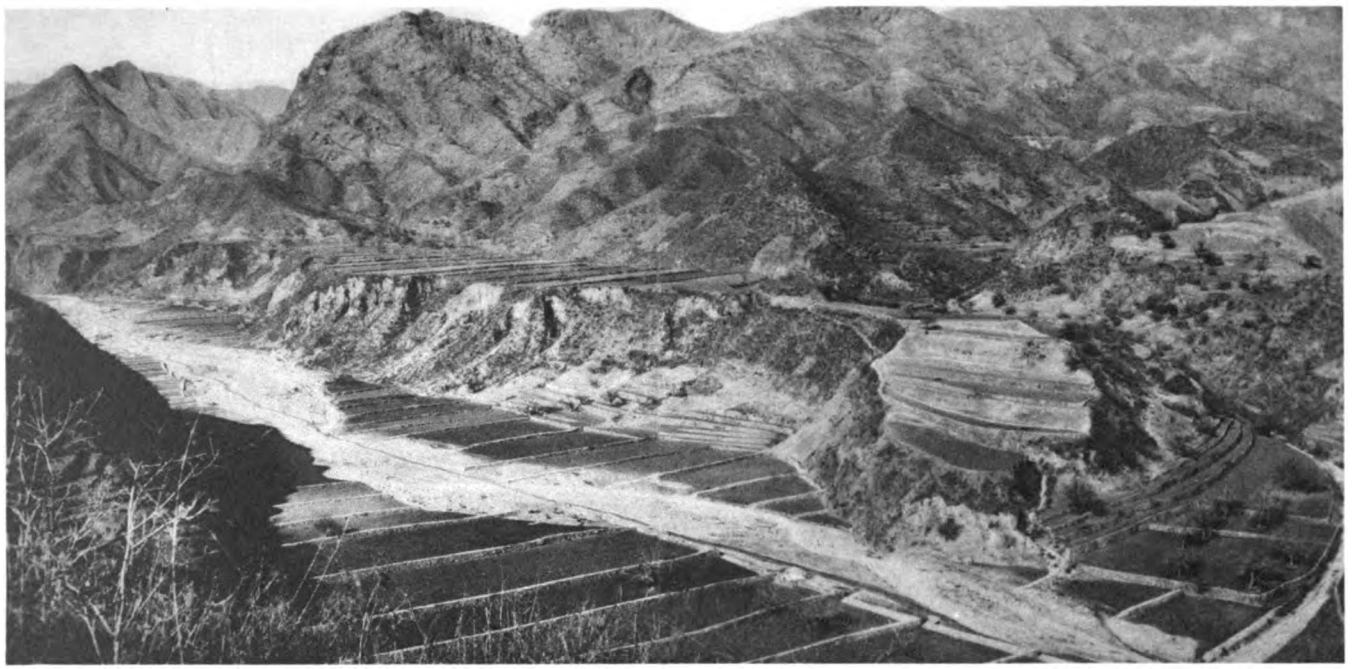
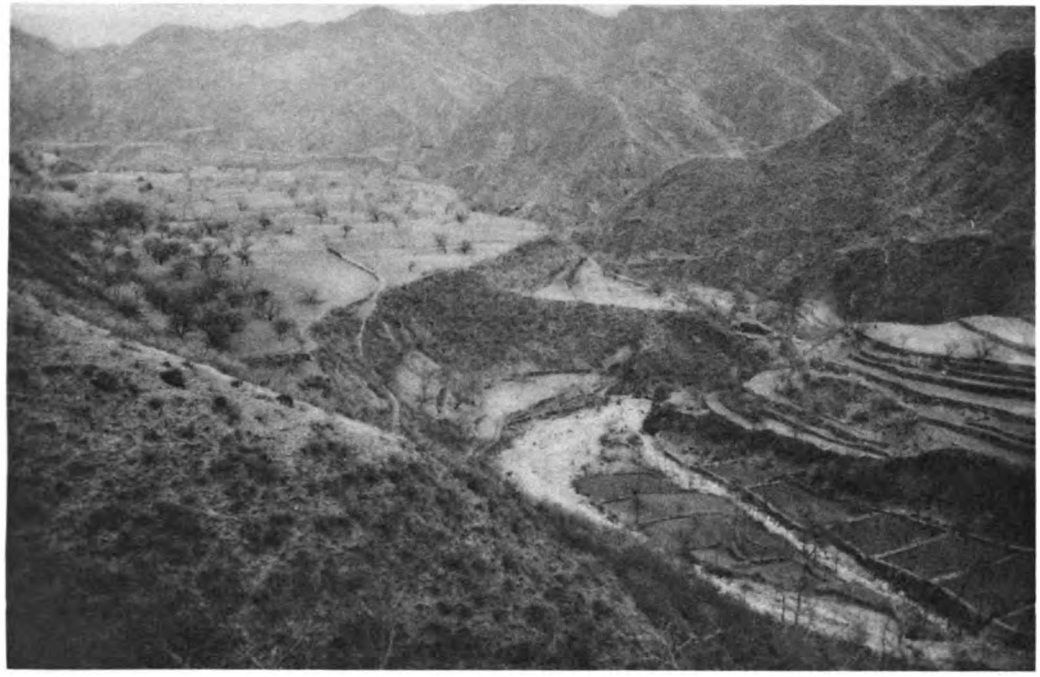
PLATES AND MAPS

Malan terrace in the lower part of the Ma Lan valley (type locality).



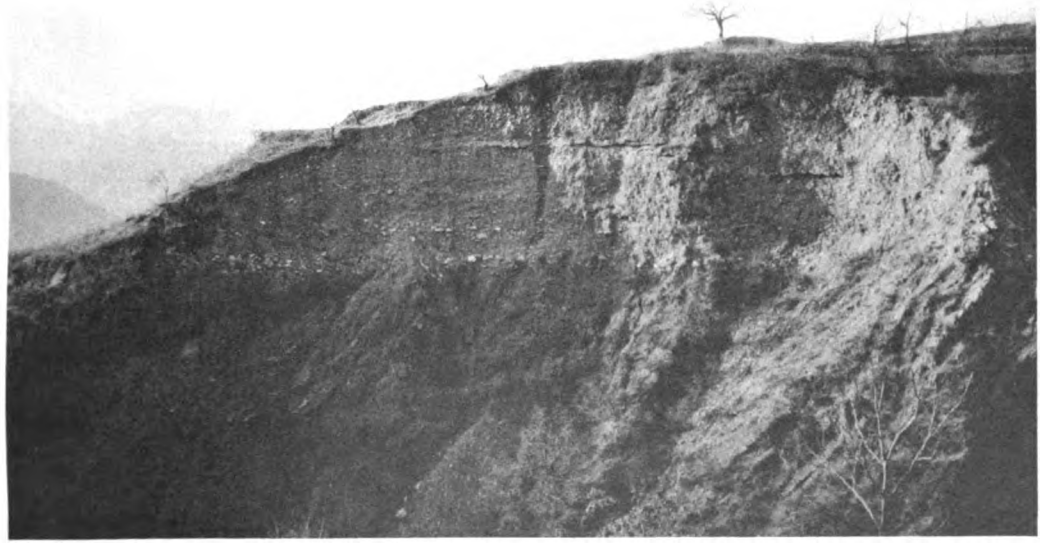
Malan terrace in the Ching Lung Chien valley.



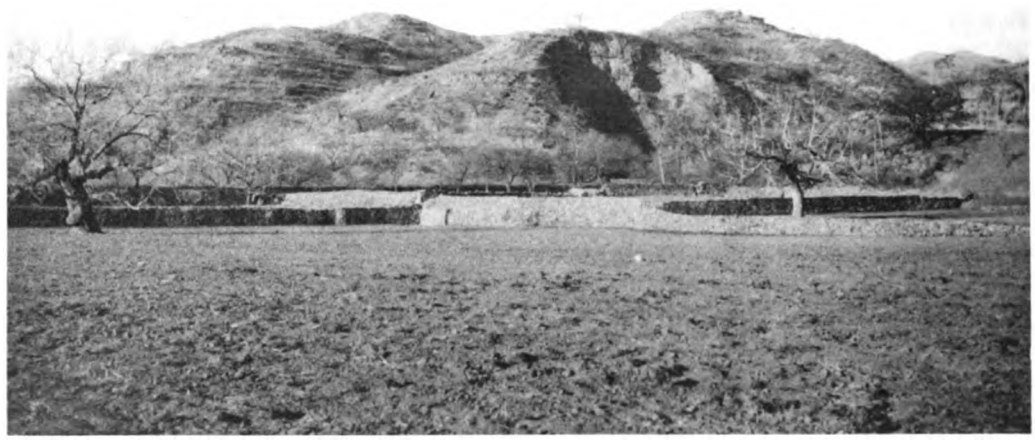
A Malan terraces in upper part of Ho Tsun valley.

B. Malan terrace in the Ching Lung Chien valley. (See Pl. II.)

A. Chai T'ang. Section through Malan terrace (height 36,3 m).



B. Section in main Chai T'ang valley at Hsi Hu Lin.
Malan stratified gravels overlaid by loess. (See Pl. V a and textfig. 5.)



A. Chai T'ang. Hsi Hu Lin. Small hills with Malan gravels overlaid by loess. (See Pl. IV b and textfig. 5.)

B. Chai T'ang. Hsi Hu Lin. Small hills with Malan gravels overlaid by loess. (See textfig. 6.)

A. Hsi Shan. Tsien Yun T'an. Canyon of Pan Chiao stage.

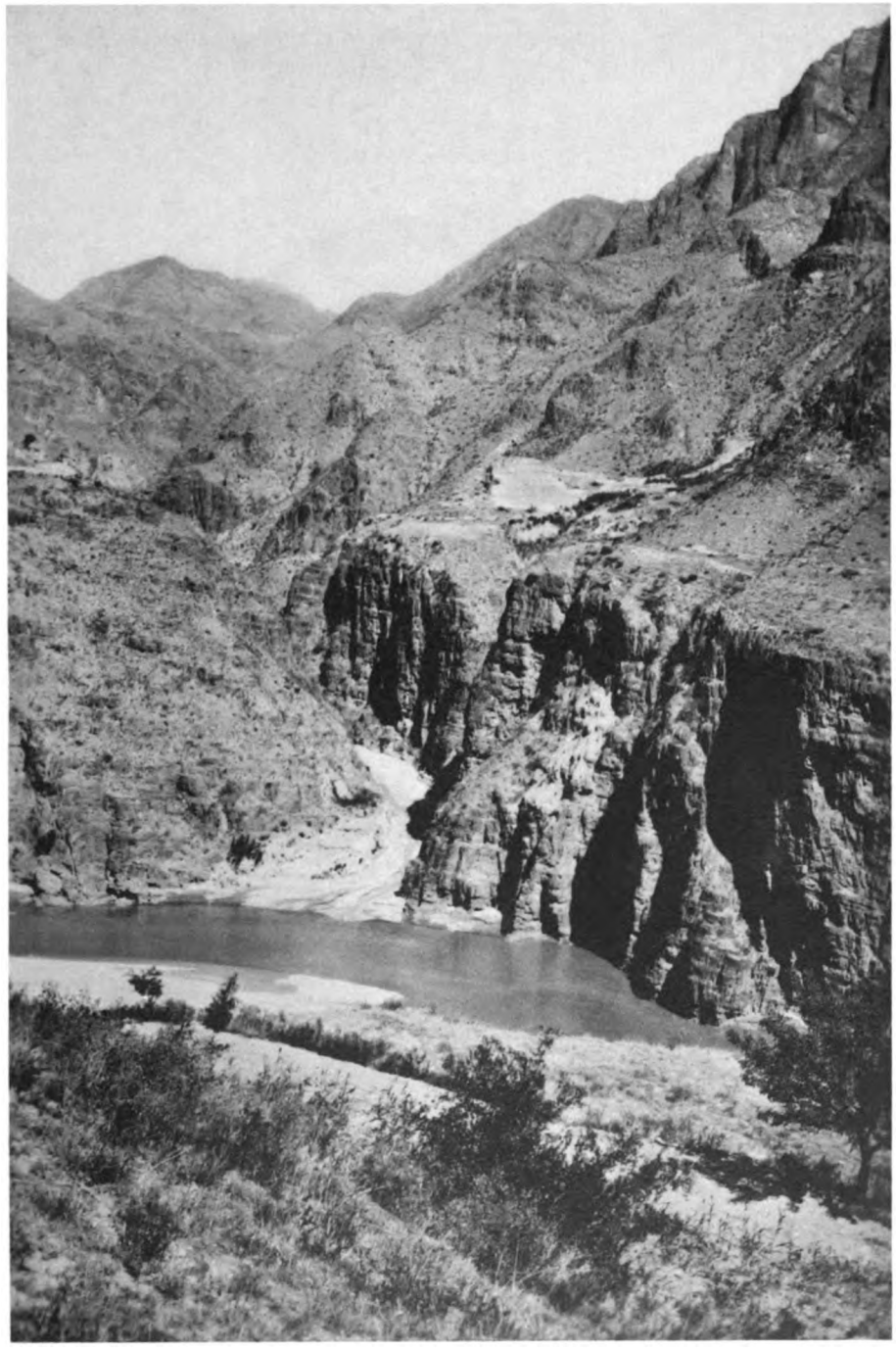
B. Hsi Shan. Pan Chiao. Canyon of Pan Chiao stage. (See textfig. 10.)

Loess country. Lung Kuan Hsien.

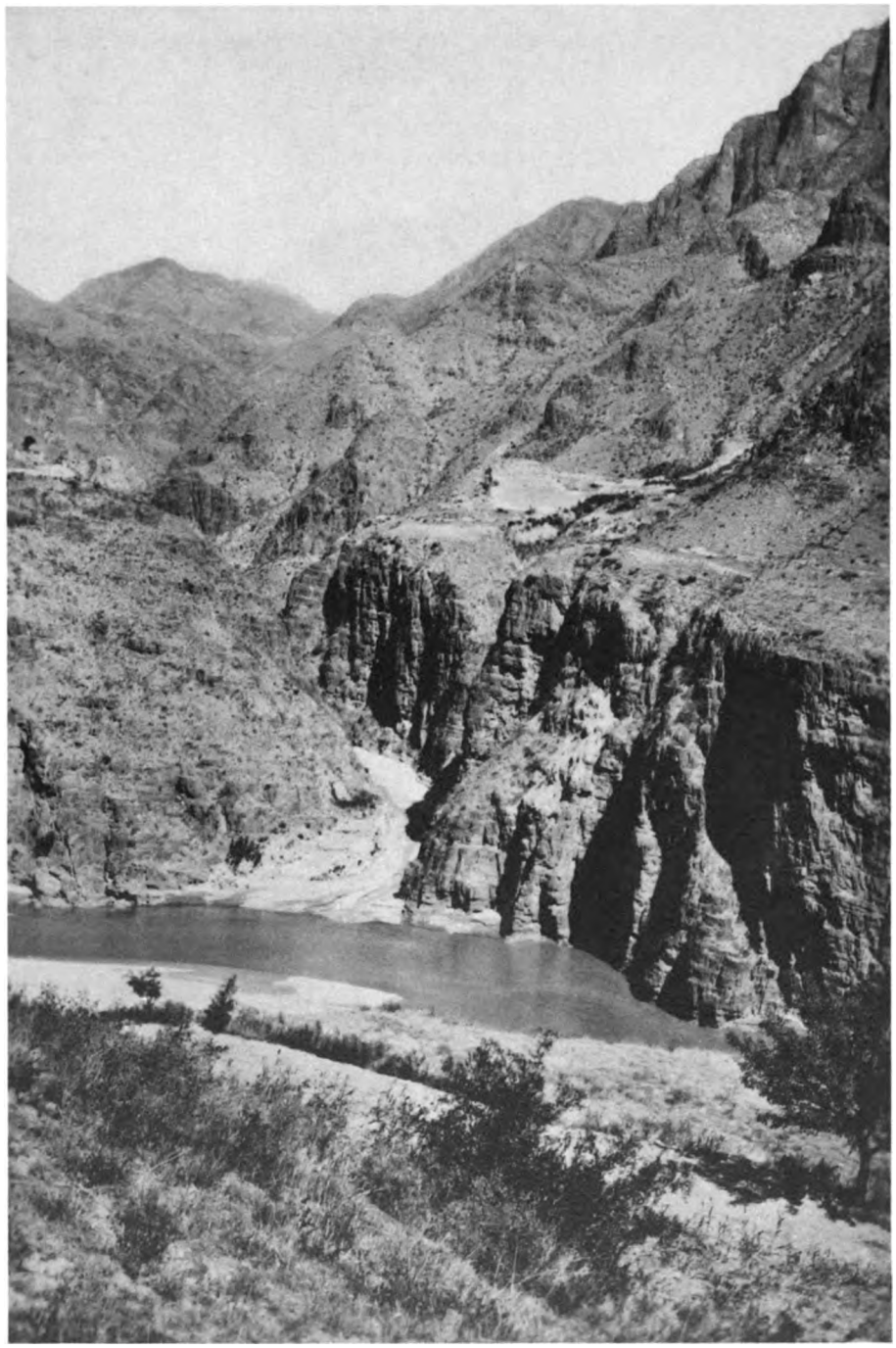
Loess country. Lung Kuan Hsien.

Entrance of the Hun Ho into the Hsi Shan canyon. Looking down river.

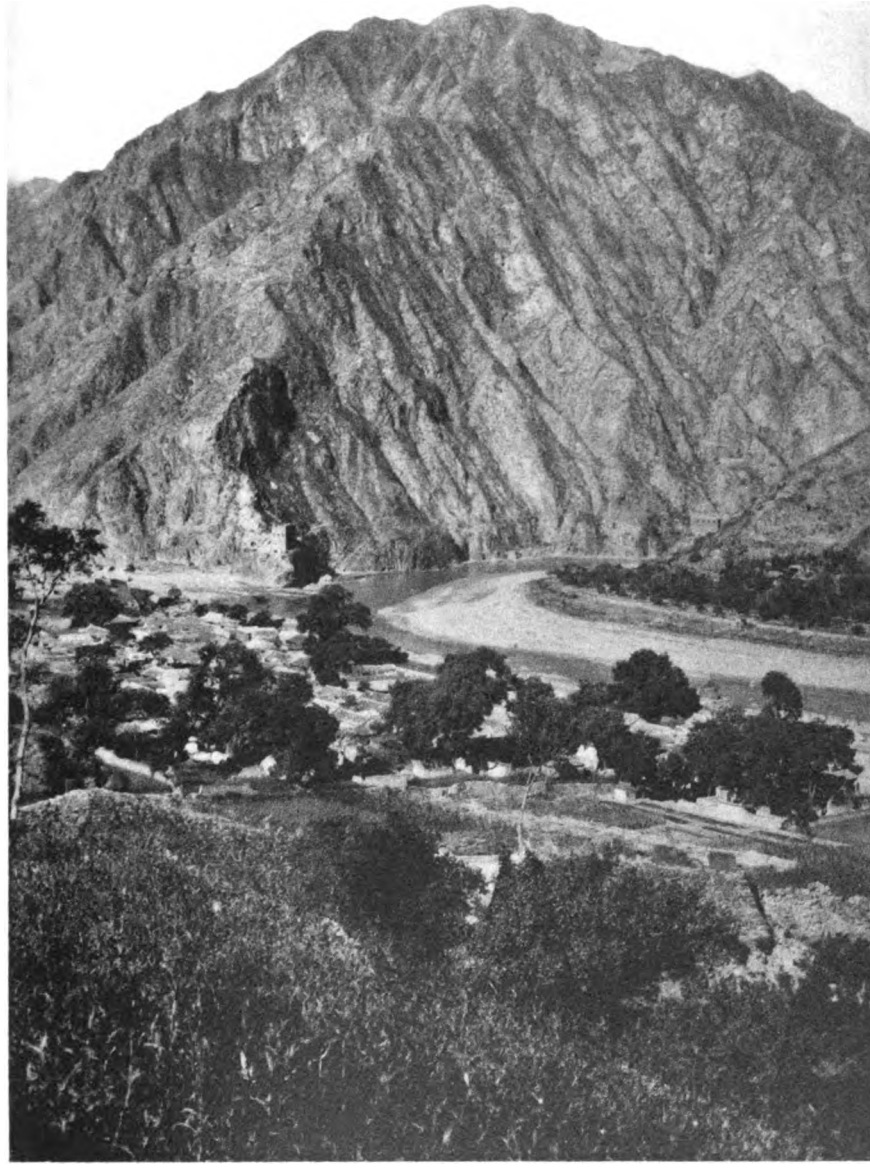
Looking up river.



Hsi Shan. Canyon of the Hun Ho.

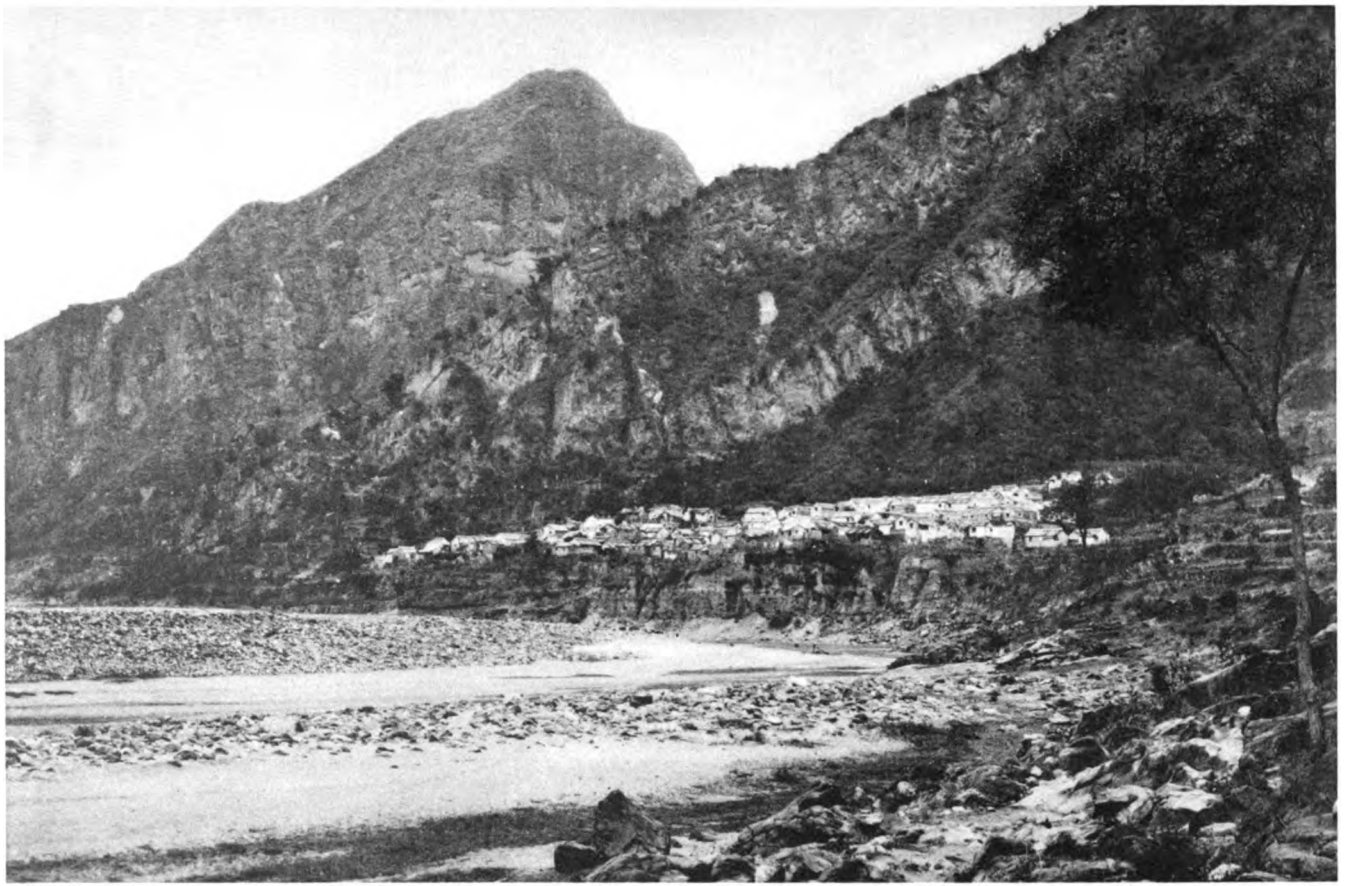


Hsi Shan. Canyon of the Hun Ho.

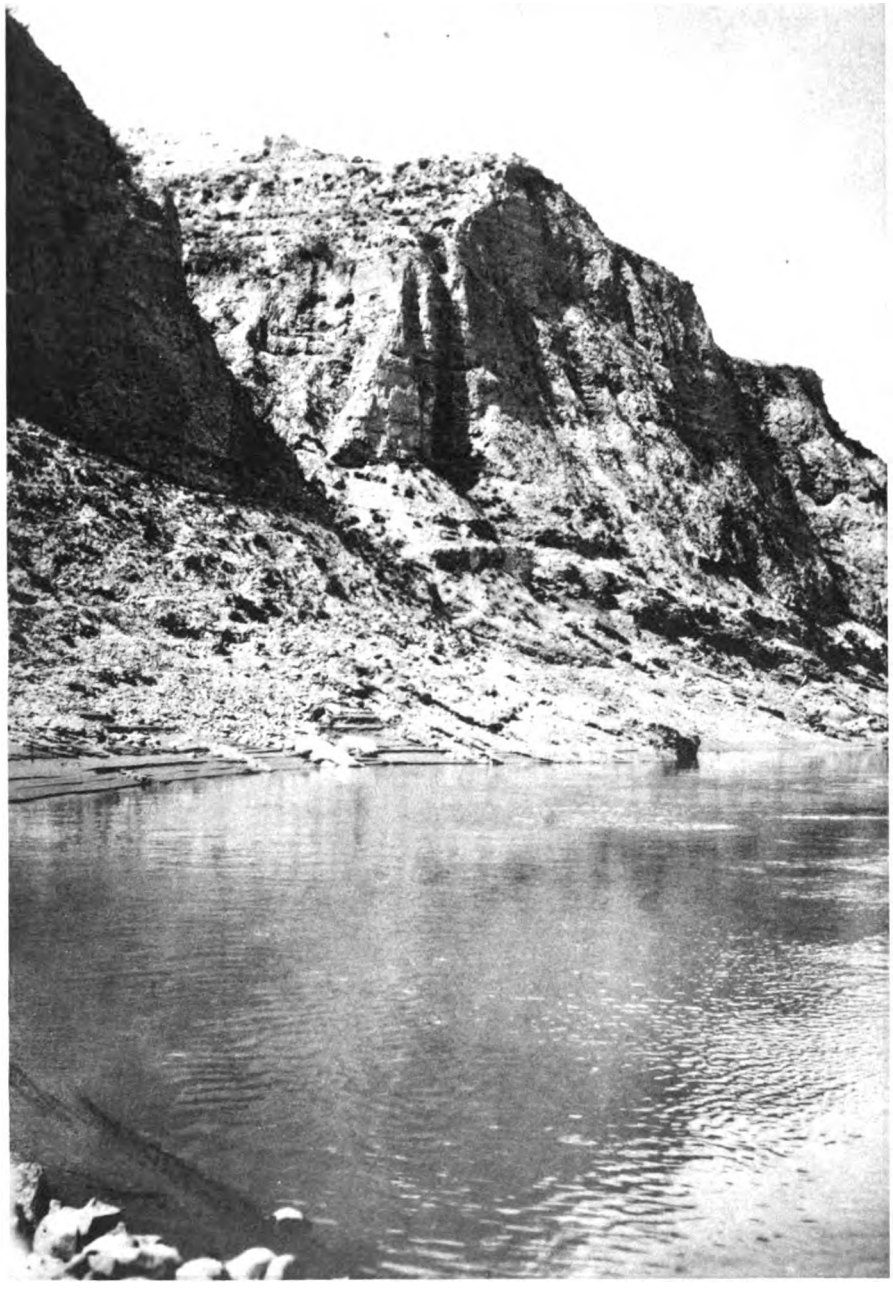


Hsi Shan. The Hun Ho at Ching Pai K'ou.

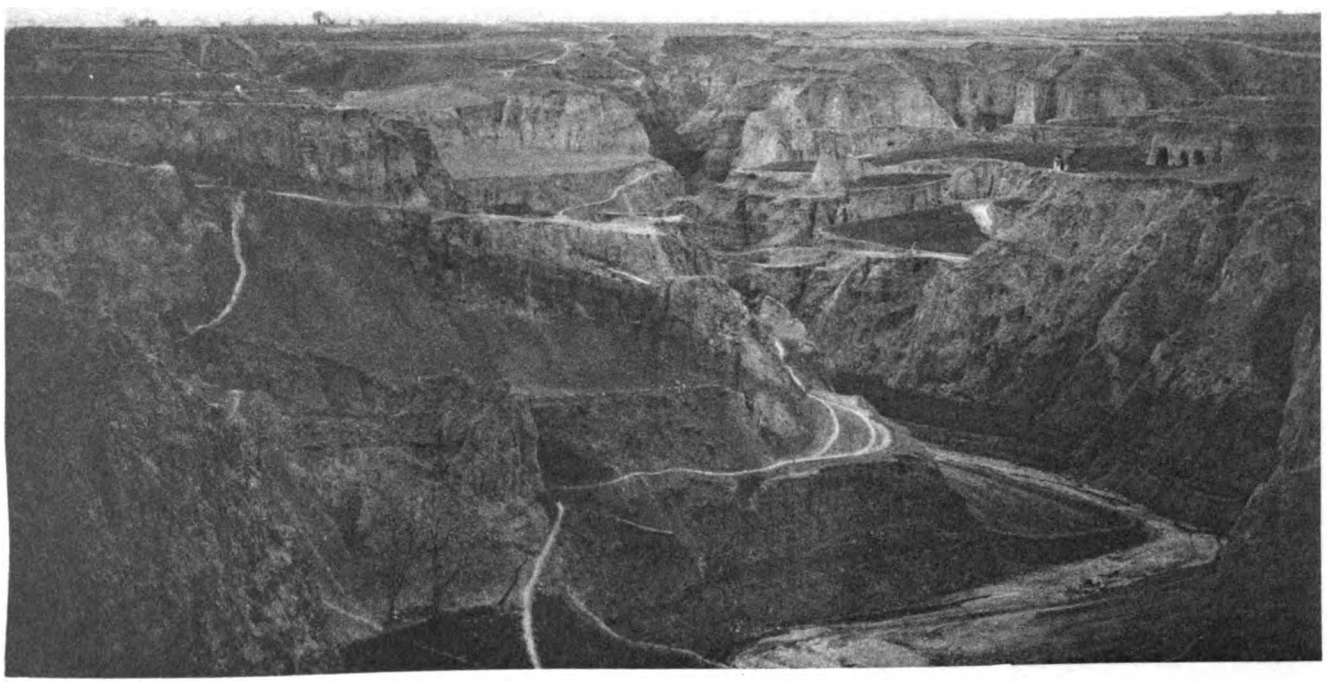
Hsi Shan. Canyon of the Hun Ho.



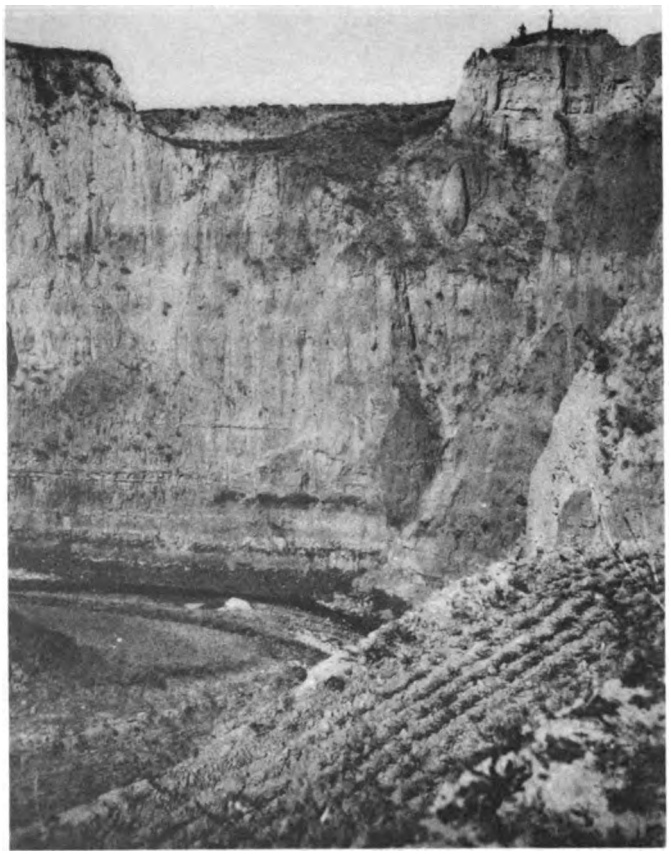
The Hun Ho and the Malan terrace at Hsia Ma Ling.

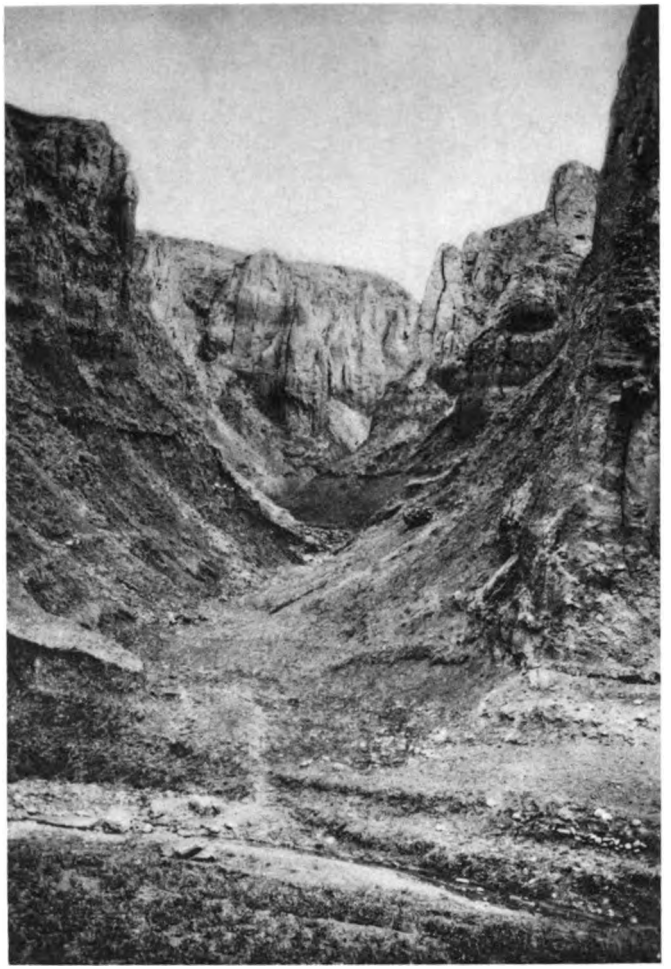


Yellow River at Ho Ti Tsun. Shansi. Fossiliferous gravels overlaid by loess.
(See textfig. 17.)



Post-Neolithic erosion. Yang Shao Tsun. Honan.

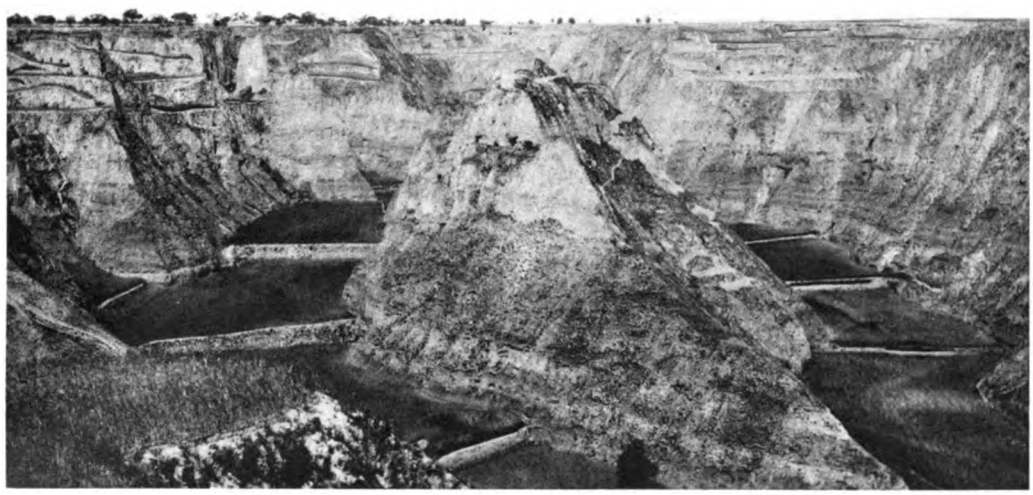




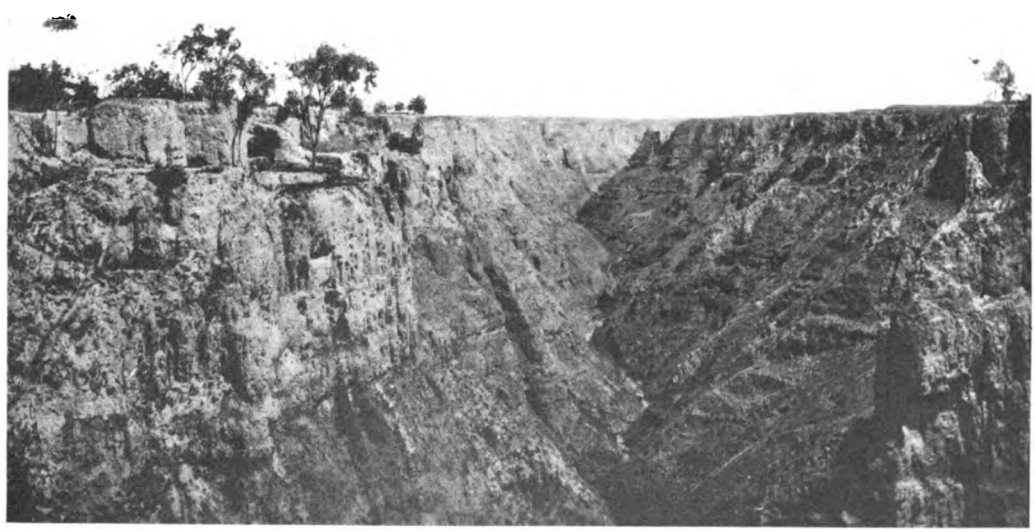
Post-Neolithic erosion. Yang Shao Tsun. · Honan.

Ravine topography. Hsü Chia Kou, Meng Tsin Hsien, Honan.

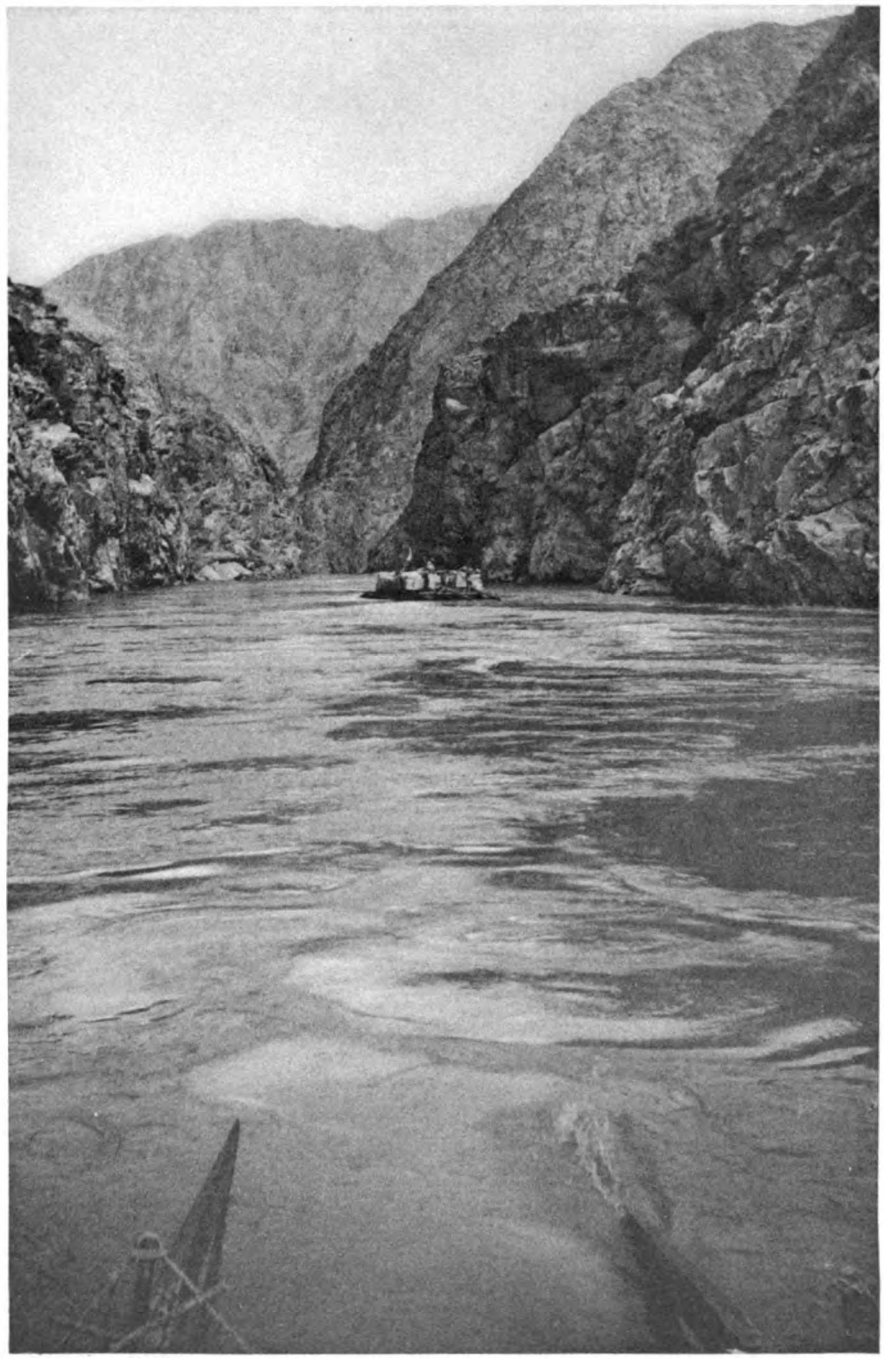
Ravine topography. Hsü Chia Kou, Meng Tsin Hsien, Honan.



Ravine topography. Hsü Chia Kou, Meng Tsin Hsien, Honan.



Ravine topography. Hsü Chia Kou, Meng Tsin Hsien, Honan.



Canyon of the Huang Ho below Lanchow.

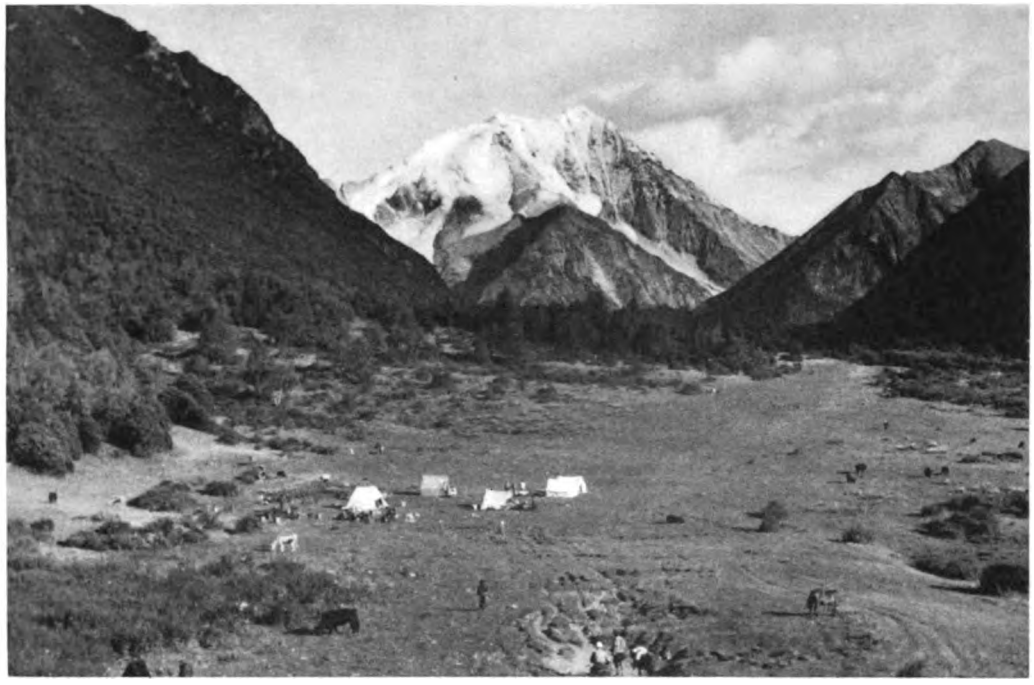
Canyon of the Huang Ho below Lanchow.

A. Kansu. The T'ao Ho valley, looking downriver from Hsin Tien »castle hill». Kuo Chia Chuang in foreground.

B. Kansu. The T'ao Ho valley, looking upriver from Hsin Tien »castle hill». Hsin Tien village in foreground.

A. T'ao valley. High hills in background dissected Malan terrace. The Hui Tsui site on hill with lone tree (textfig. 34).

B. T'ao valley at T'ao Sha Hsien. M-M Malan terrace. H. High dissected terrace.



A. Hsi Kang. Beilokoko valley with Minya Zara in background.

B. Moraine-dammed lake at the foot of Minya Zara.

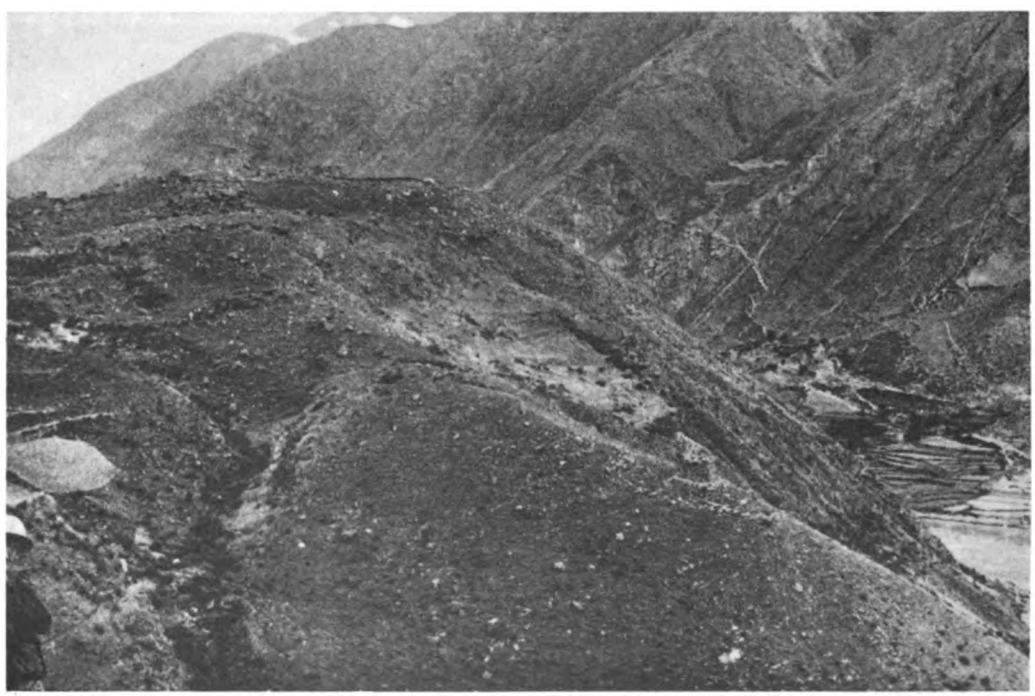
A. Hsi Kang. Glacier-stream of Minya Zara looking upstream.

B. Glacier-stream of Minya Zara looking downstream.

A. Hsi Kang. Glacier-stream of Minya Zara looking upstream.

B. Glacier-stream of Minya Zara looking downstream.

A. Hsi Kang. Boulder-strewn slope of terminal moraine above Lu Ting Chiao.



B. The terminal moraine above Lu Ting Chiao.

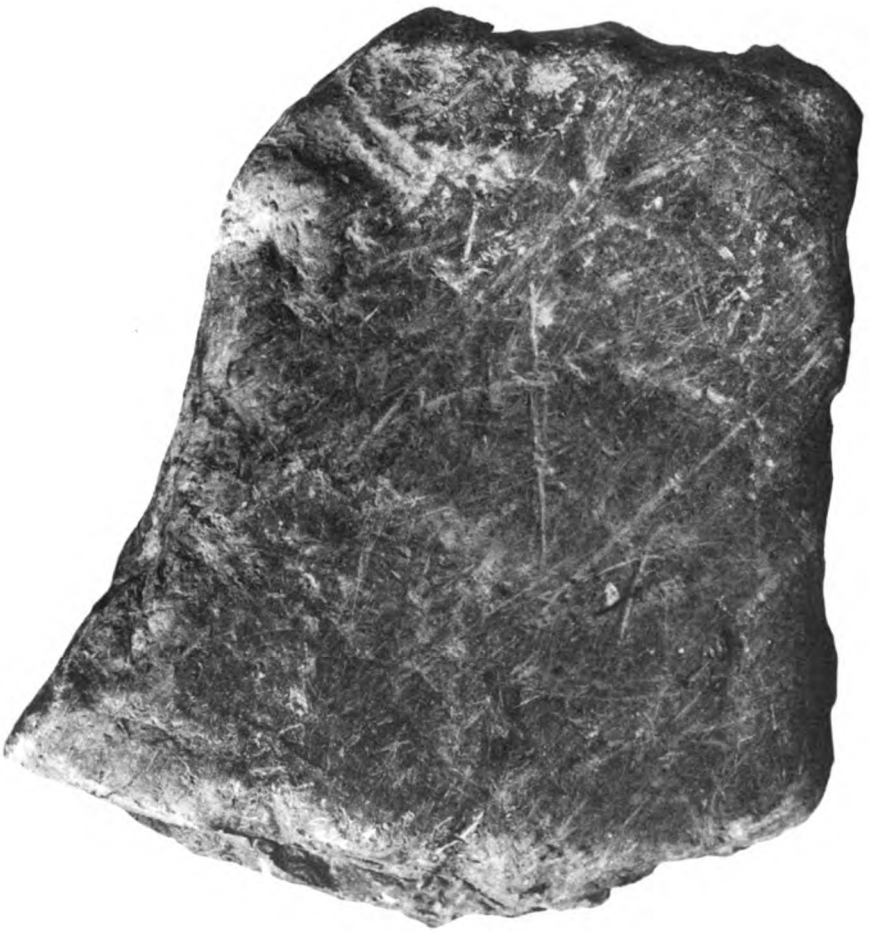
A. Hsi Kang. The ground-moraine deposit of Zurahaki.

B. Hsi Kang. The ground-moraine deposit of Zurahaki.

Hsi Kang. Striated boulder of the Zurahaki ground-moraine.

A. Hsi Kang. The pass Gachala with roadcut in ground-moraine.

B. Boulder-strewn slope of Hsin Tien terminal moraine.



Hsi Kang. Striated boulder of Gachala ground-moraine. Size slightly reduced.

A. Spur of old valley bottom (Malan stage?). Between Hanyuan and Lu Ting Chiao.

B. Hsi Kang. Canyon in limestone. Above Hanyuan.

Hsi Kang. Malan terrace below Yachow.

A. Hsi Kang. Ravaka. Slightly dissected Malan valley surface.

B. Ravaka. Spur of the old Malan valley surface.

A. Hsi Kang. From La Bren To camp looking downstream. Nearly unbroken Malan valley surface. Narrow erosion channels at both valley sides.

B. From La Bren To camp looking upstream. Unbroken Malan valley surface.

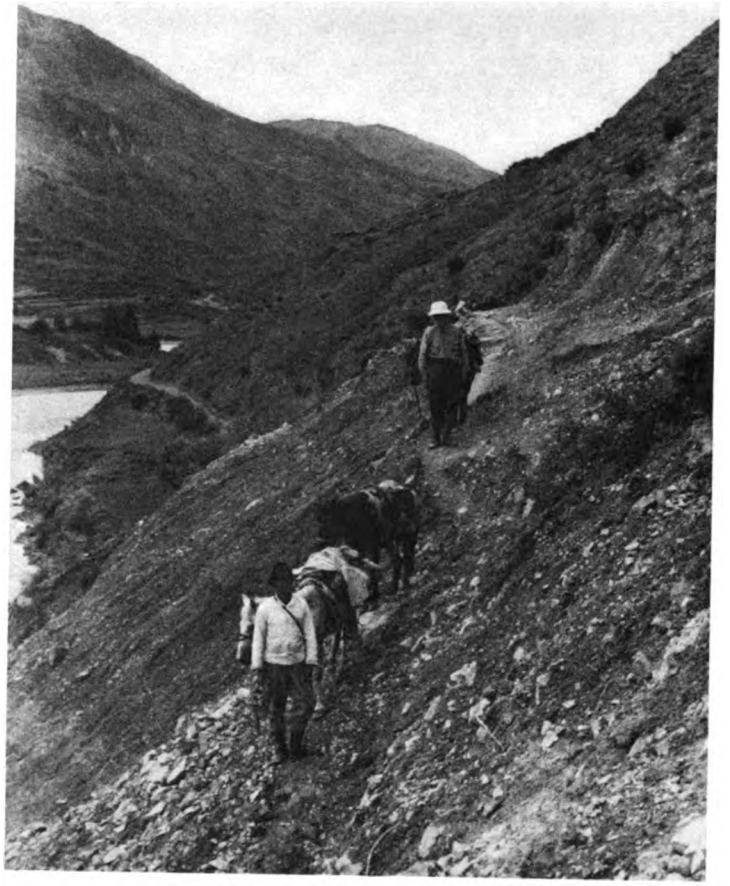
A. Hsi Kang. From La Bren To camp looking downstream. Nearly unbroken Malan valley surface. Narrow erosion channels at both valley sides.

B. From La Bren To camp looking upstream. Unbroken Malan valley surface.

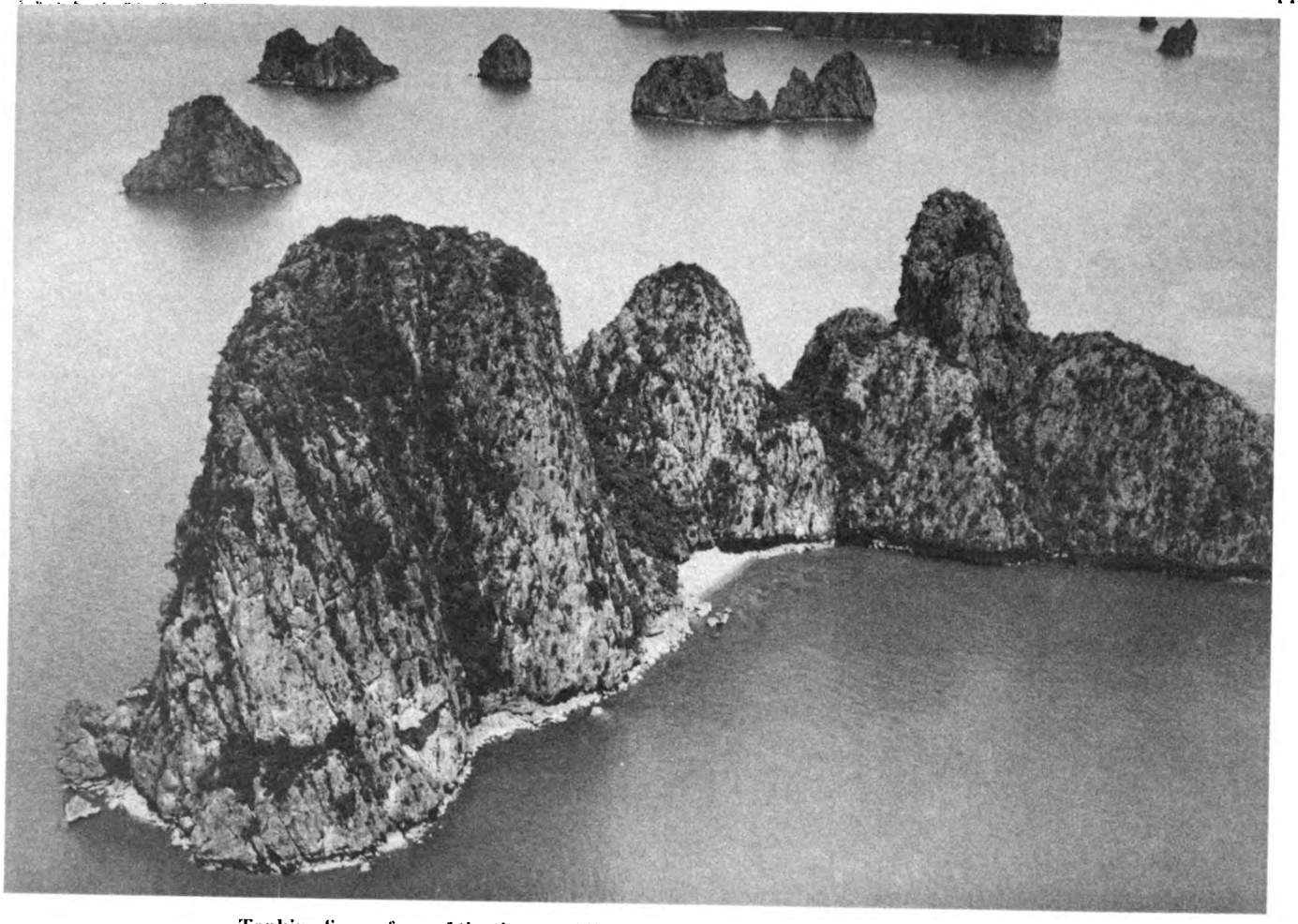
A. Hsi Kang. Unbroken Malan valley surface.

B. Hsi Kang. Unbroken Malan valley surface.

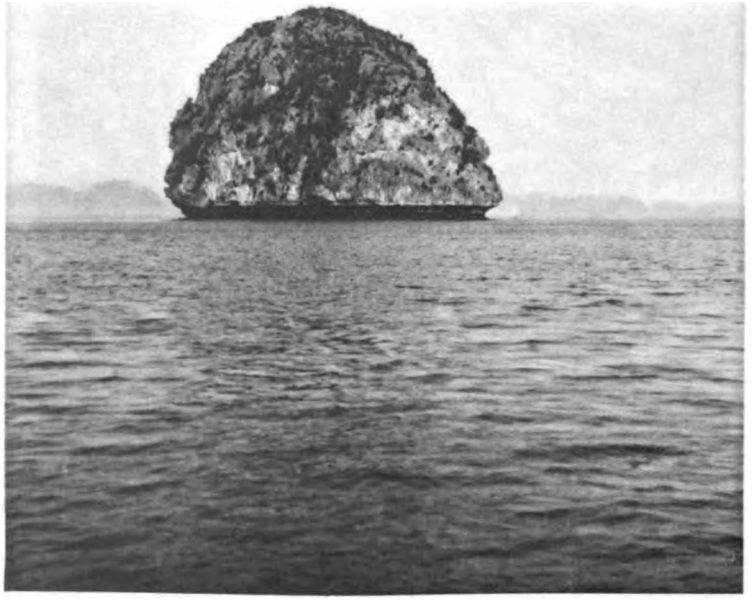
Hsi Kang. The Rotsung-Cholöna terrace complex.



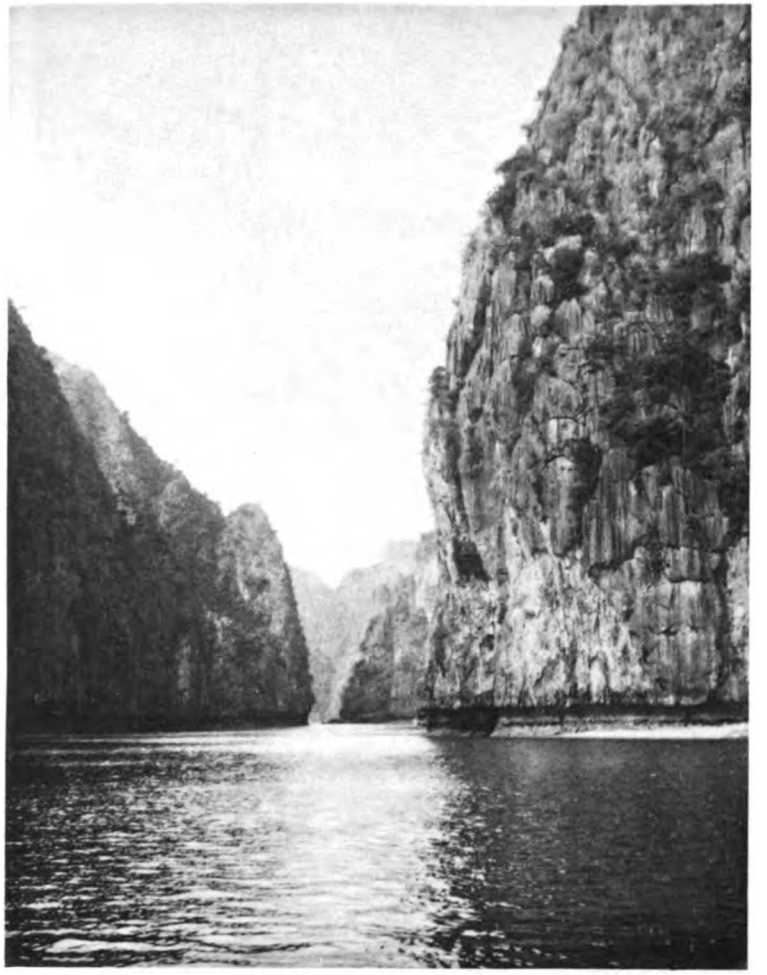
Hsi Kang. Above: The Rotsung R_1 site.
Right: Crossing landslide NW from Chung-da.



Tonkin. Some few of the thousand limestone islets of the Fai Tsi Long archipelago.
Courtesy of the French Air Force.



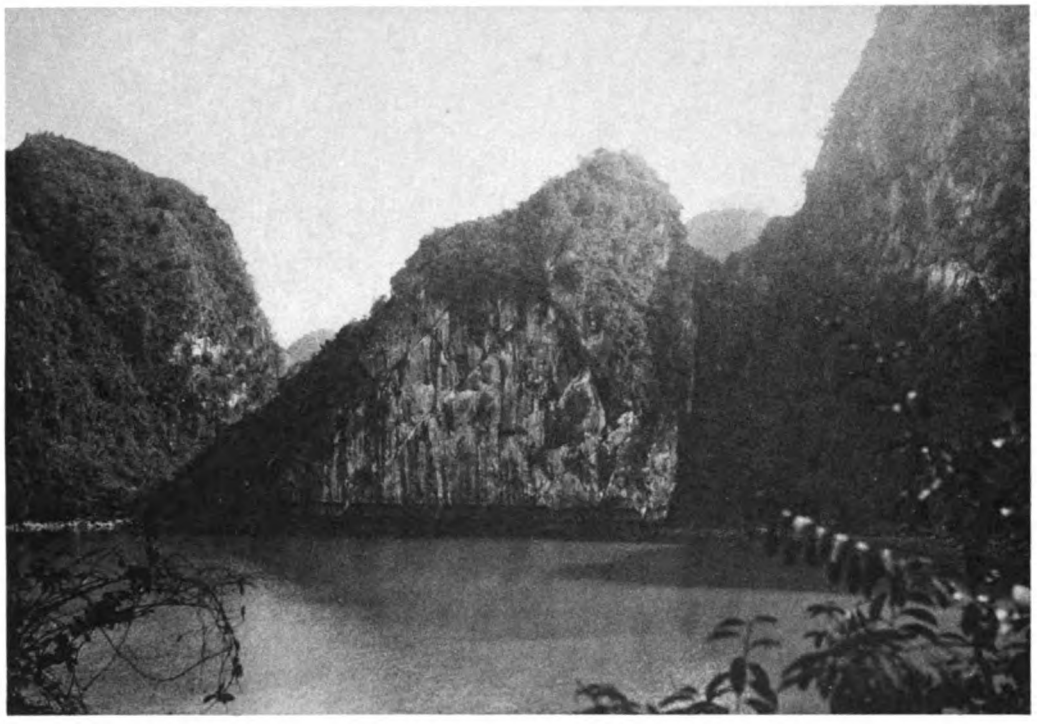
A. Tonkin. Fai Tsi Long. Strawberry-shaped limestone islet.



B. Ile de l'Union. Anse de la Croix.

A. Tonkin. Fai Tsi Long. Limestone islet. Coastal cliff with »Regenrillen« and marine undercutting.

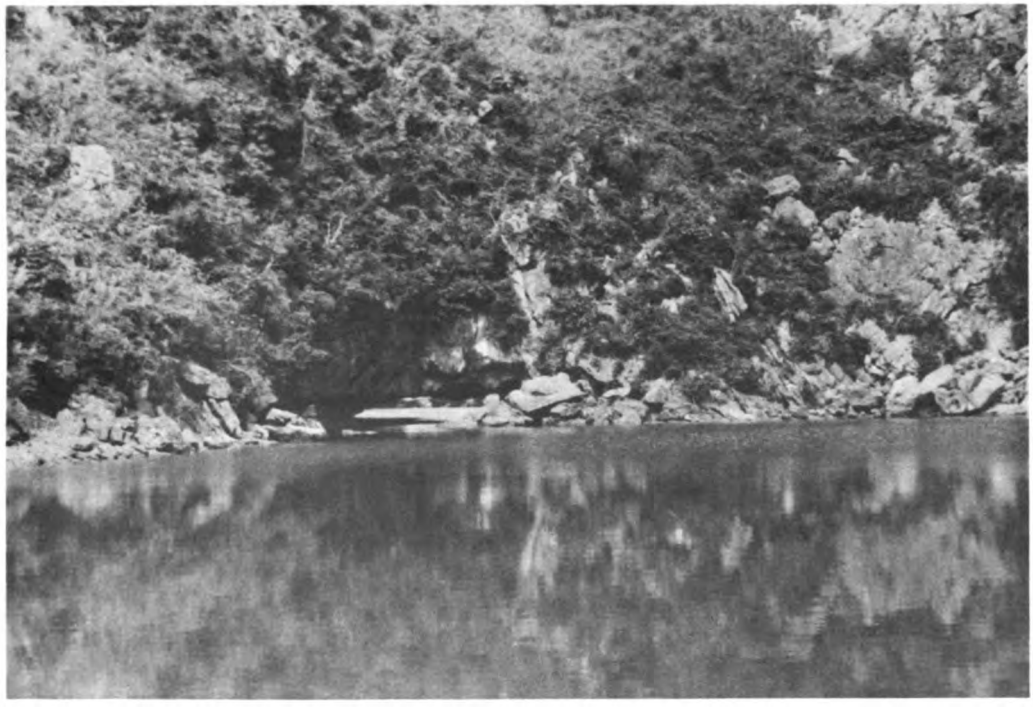
B. Tonkin. Fai Tsi Long. Limestone islet. Coastal cliff with marine undercutting.



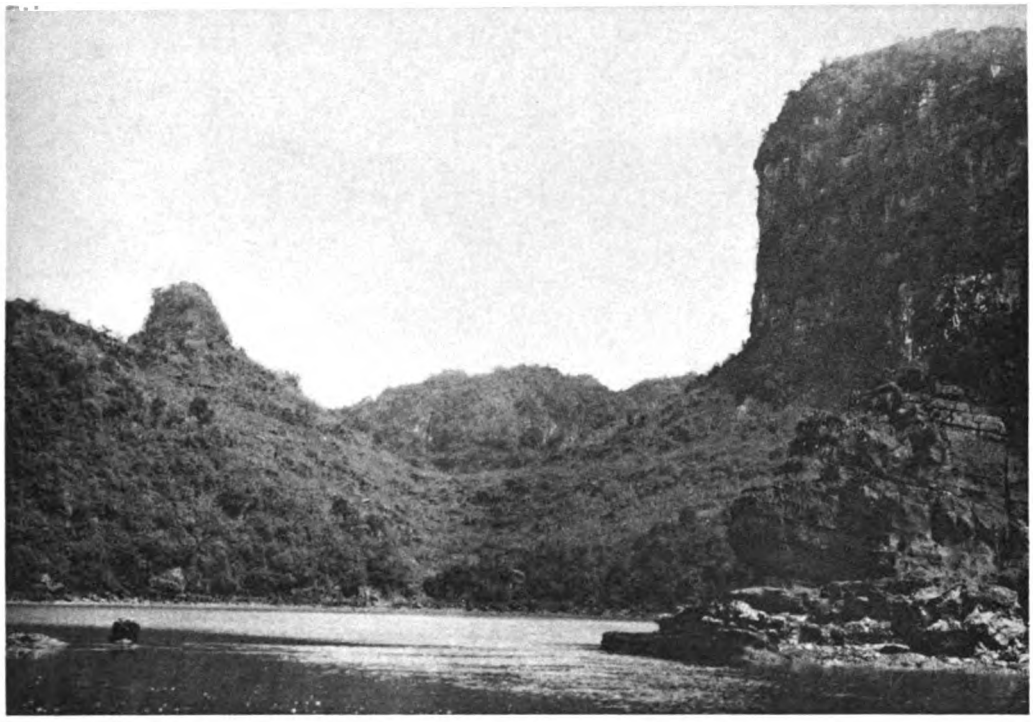
A. Fai Tsi Long archipelago. Ile de l'Union. »Cirque» with »Regenrillen» and marine undercutting.

B. Ile de l'Union. Limestone cliff with cactus-vegetation.

A. Tonkin. Fai Tsi Long archipelago. Ile de l'Union. NW Cirque.

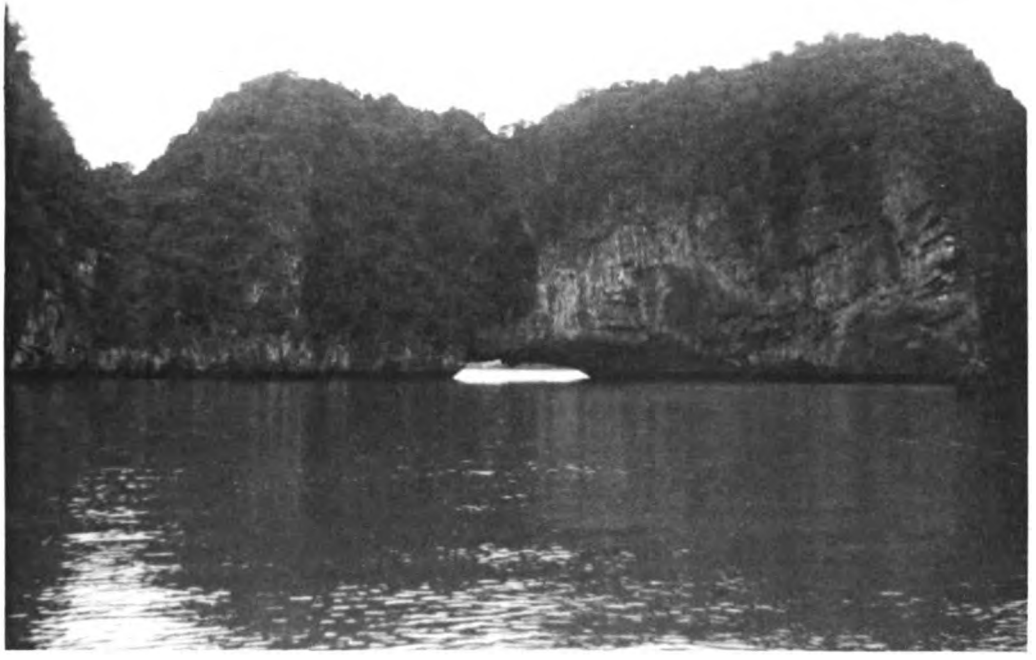


B. Tunnel-like entrance to NW Cirque.

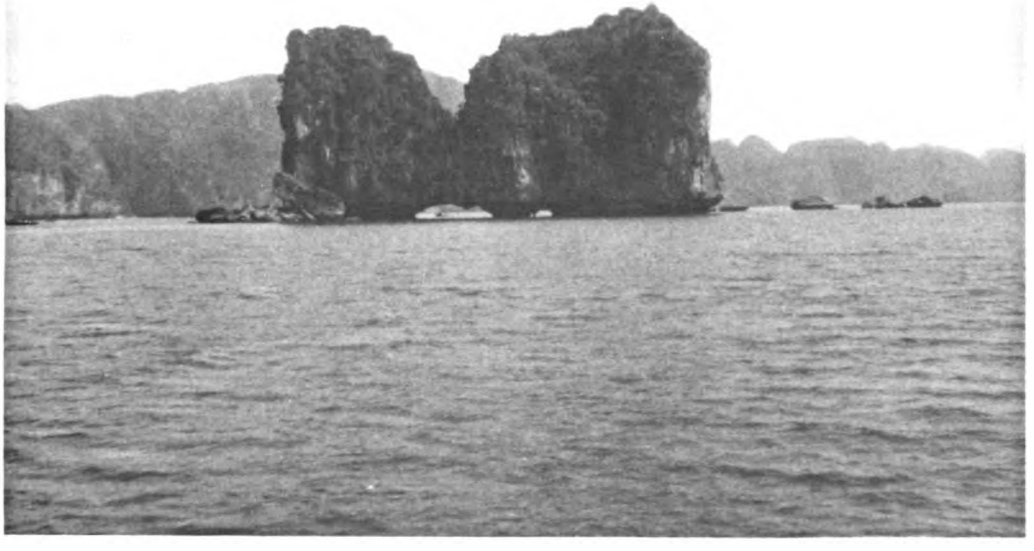


A. Tonkin. Fai Tsi Long archipelago. Ile des Deux Cirques. Entrance to the demicirque and low barrier of eastern cirque.

B. Mangrove-growth in eastern cirque.



A. Tonkin. Fai Tsi Long archipelago. Rock-arch formed by the dissolving action of the seawater.



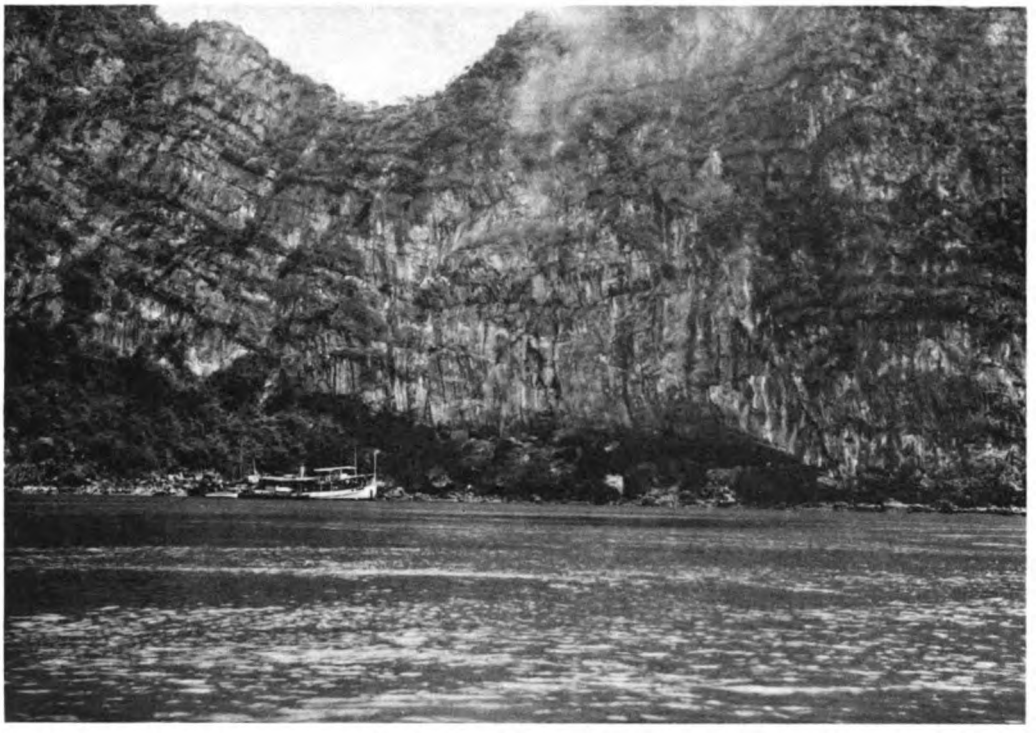
B. Tonkin. Fai Tsi Long archipelago. Rock-arches formed by the dissolving action of the seawater.

A. Tonkin. Fai Tsi Long archipelago. Fanciful limestone pinnacles formed by subaerial action.

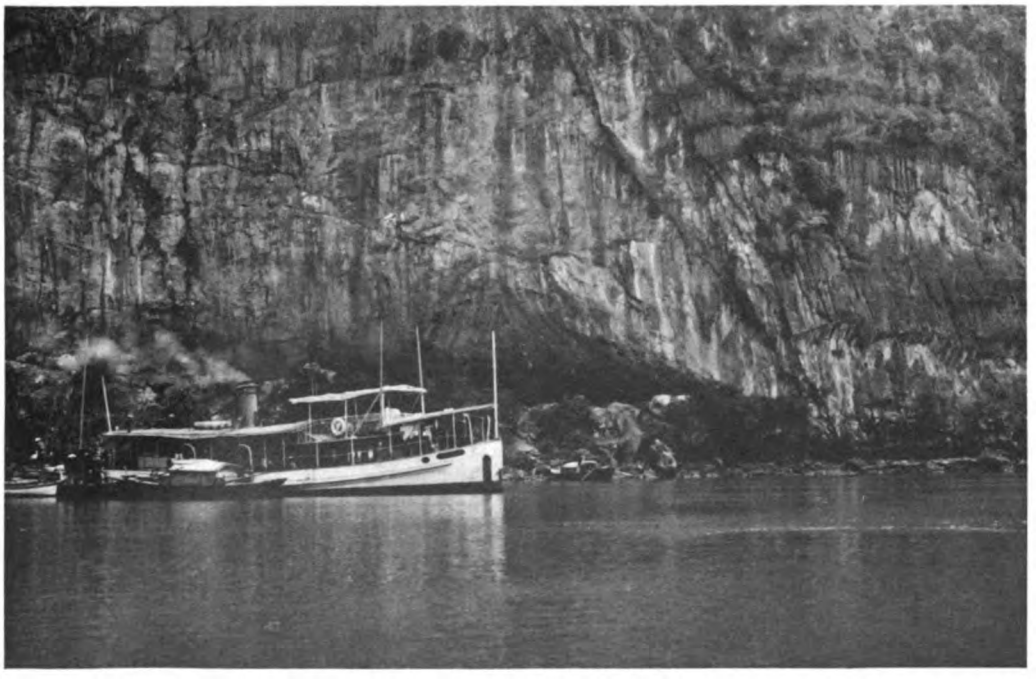
B. Tonkin. Fai Tsi Long archipelago. Fanciful limestone pinnacles formed by subaerial action.

A. Tonkin. Fai Tsi Long archipelago. Fanciful limestone pinnacles formed by subaerial action.

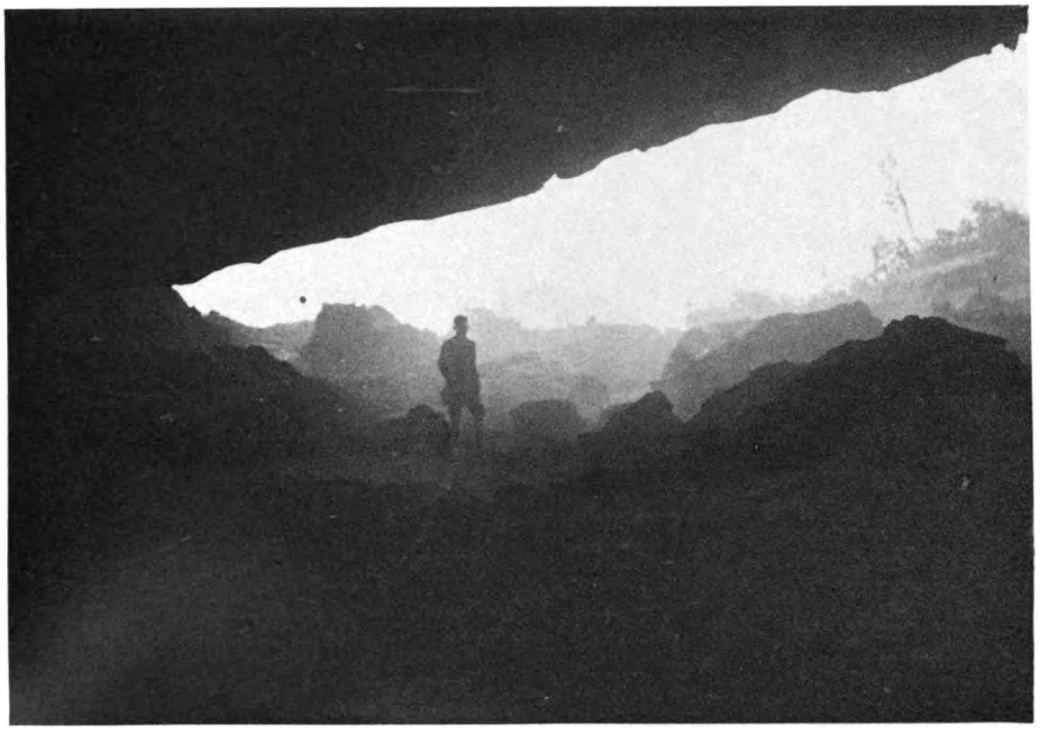
B. Tonkin. Fai Tsi Long archipelago. Fanciful limestone pinnacles formed by subaerial action.



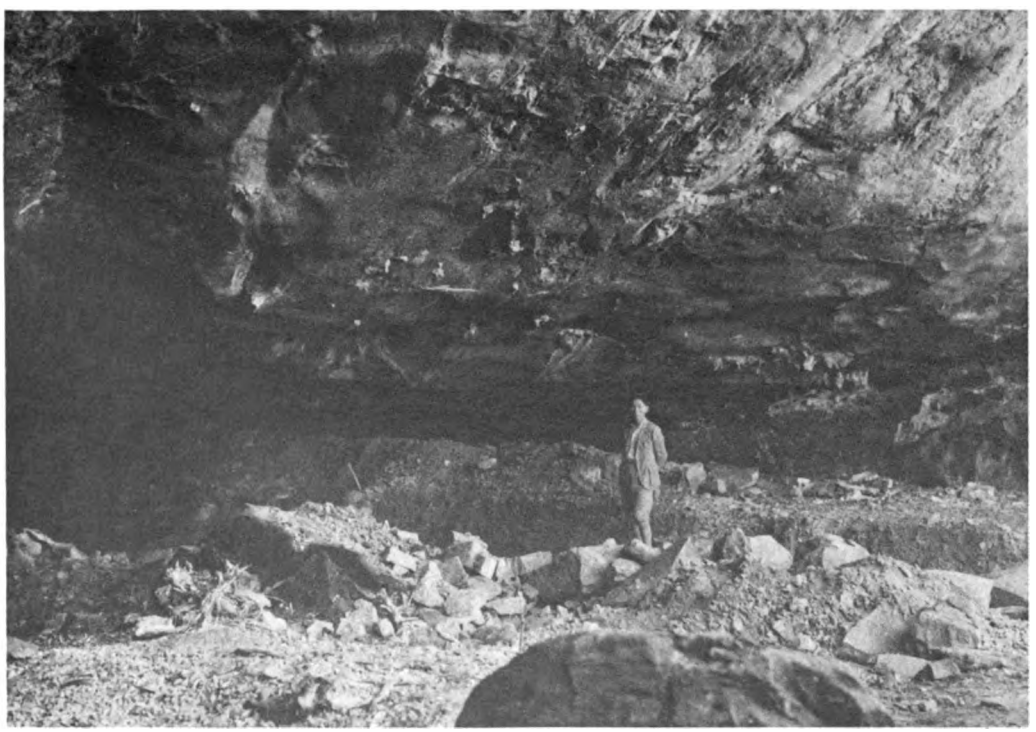
A. Tonkin. Fai Tsi Long archipelago. Ile des Grottes. Entrance to the cave. (Grotte du Ciseau.)



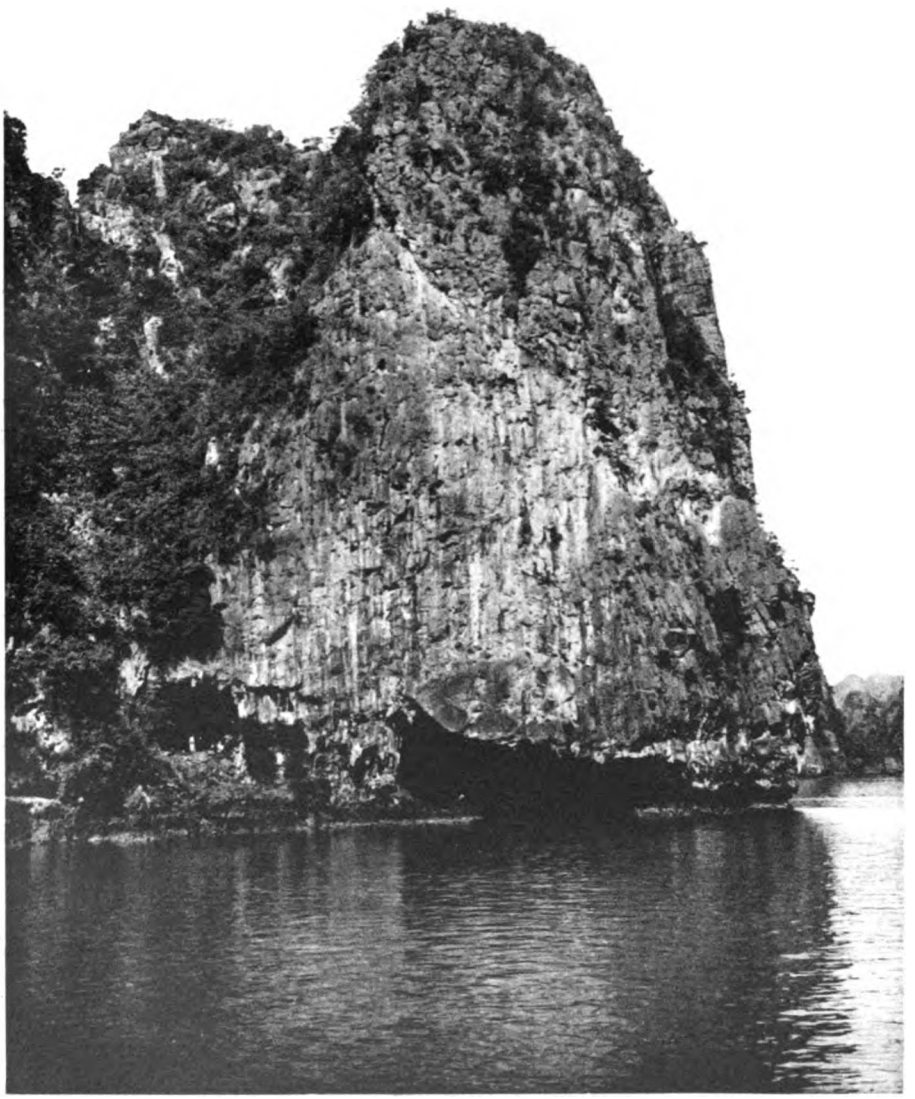
B. Tonkin. Fai Tsi Long archipelago. Ile des Grottes. Entrance to the cave. (Grotte du Ciseau.)



A. Tonkin. Ile des Grottes. Southern half of the entrance of Grotte du Ciseau.

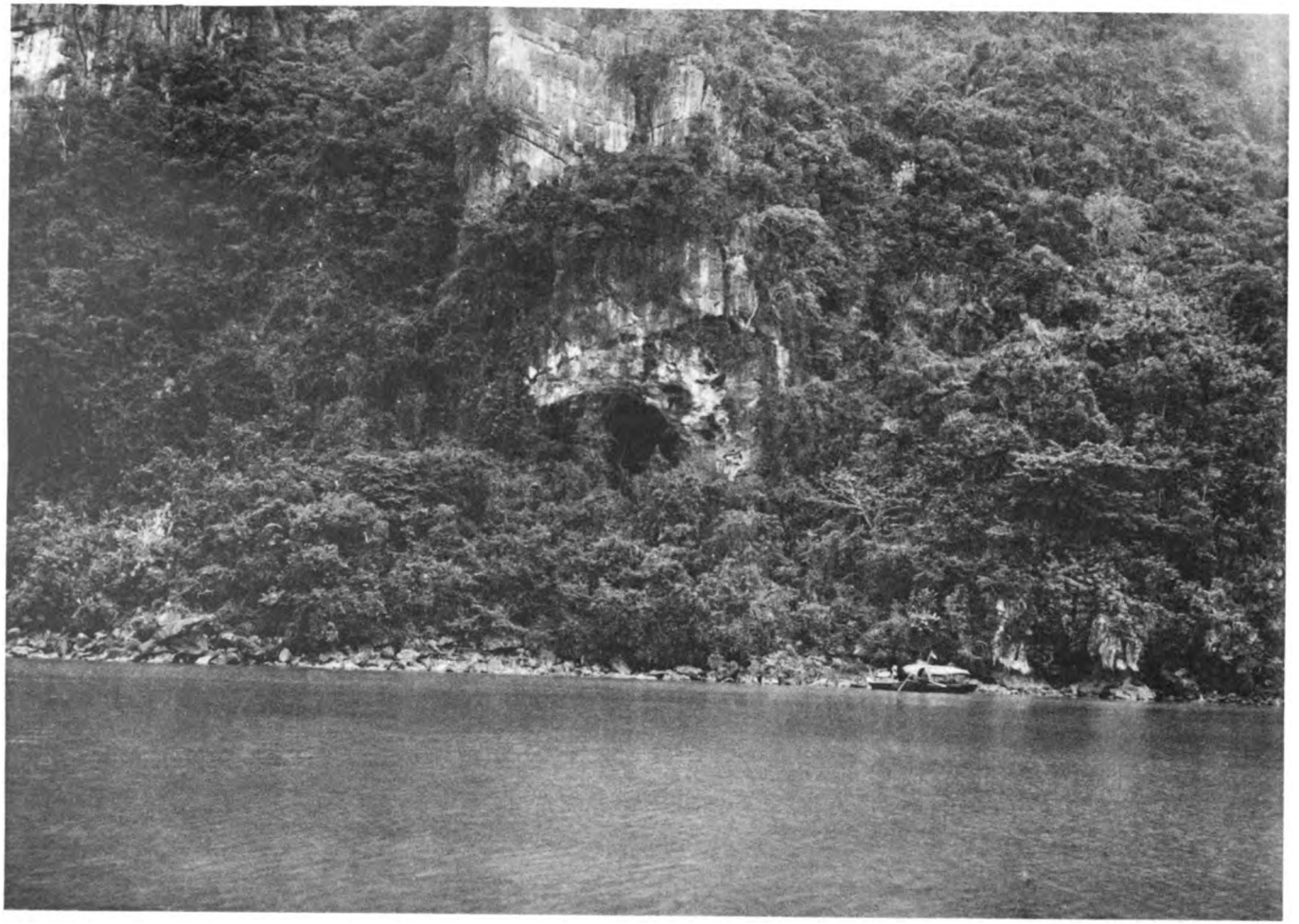


B. Grotte du Ciseau. M. Tran standing by the big trench.



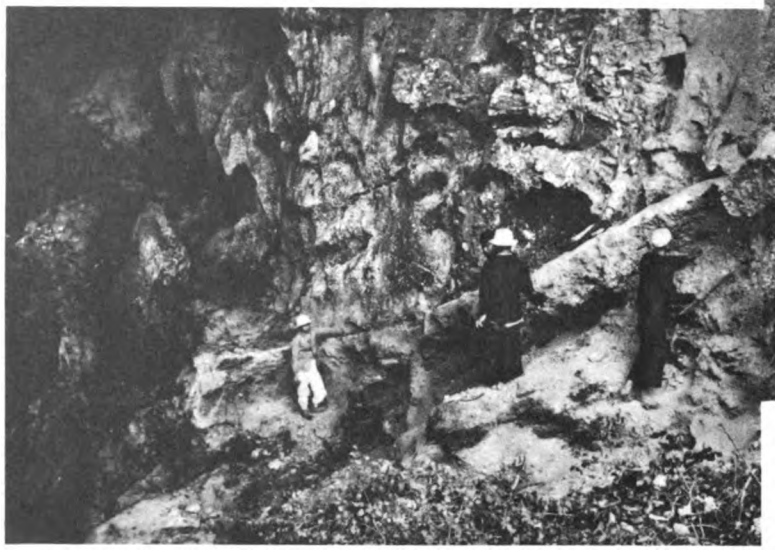
Tonkin. Fai Tsi Long. Ilot de la Grotte des Coquilles. Northern part showing modern cave.

Ilot de la Grotte des Coquilles. Showing modern and ancient cave.

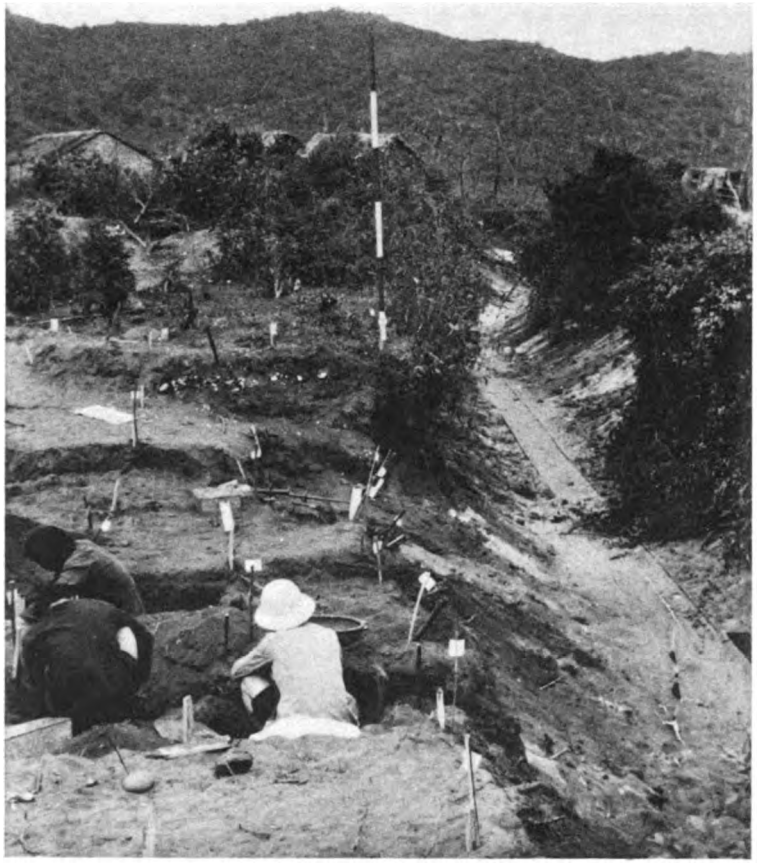


Tonkin. Fai Tsi Long. Entrance to Grotte des Sylphes.

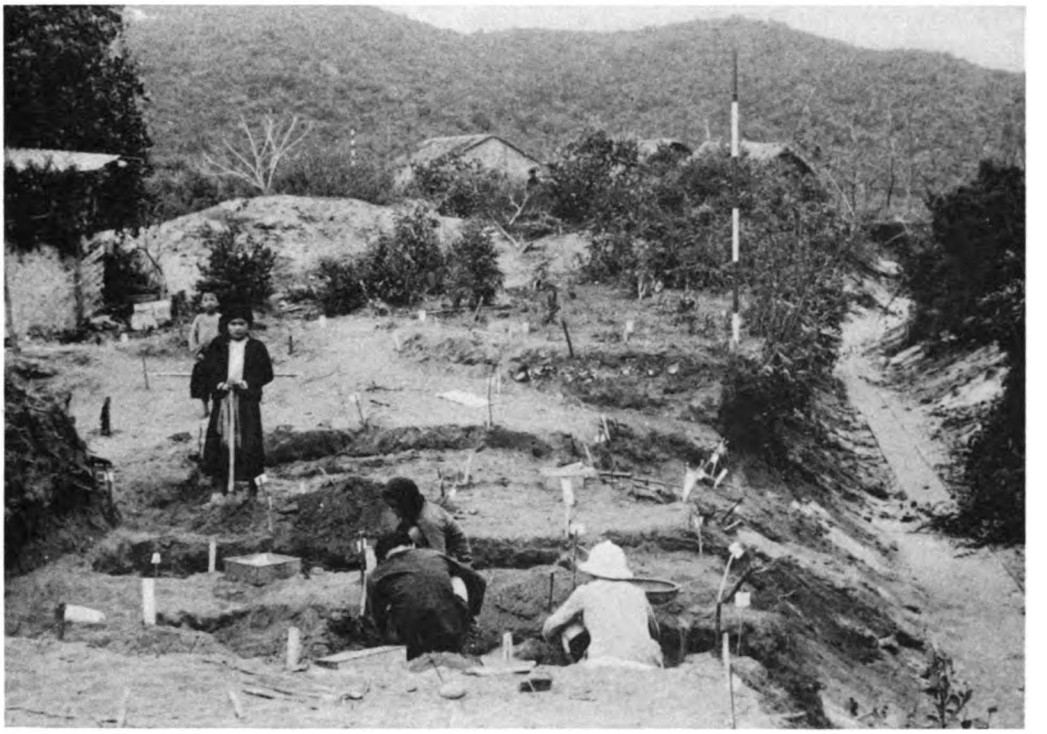
Grotte des Sylphes.



Excavating the steeply inclined shell sediment.



Excavation of the Danh Do La site.

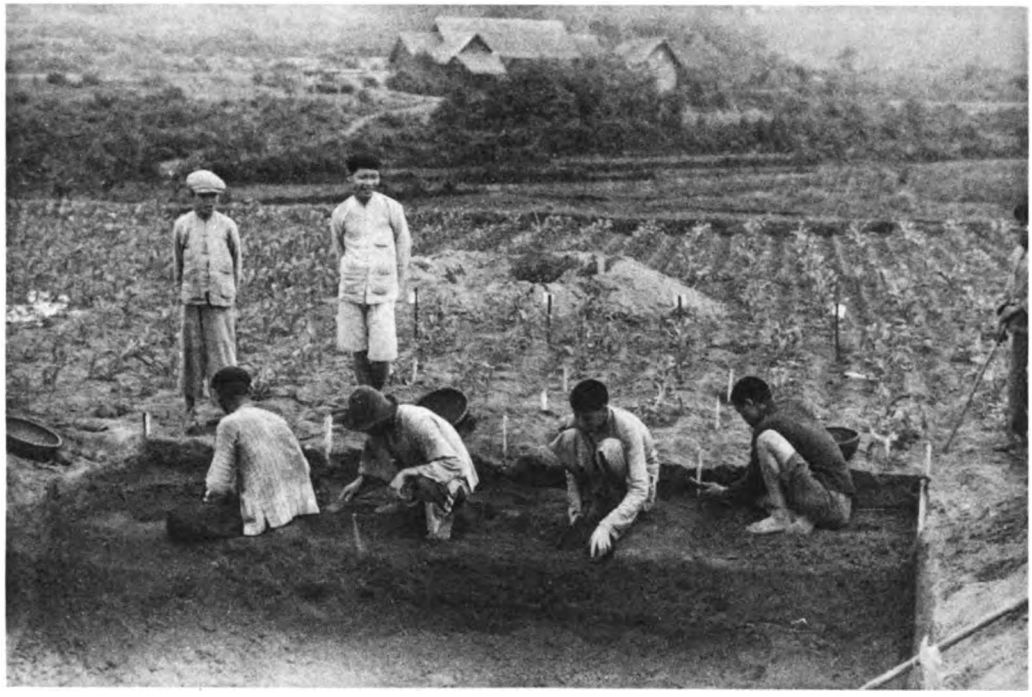


A. Excavation of the Danh Do La site.

B. Excavation of the Danh Do La site.

A. Excavation of the Danh Do La site.

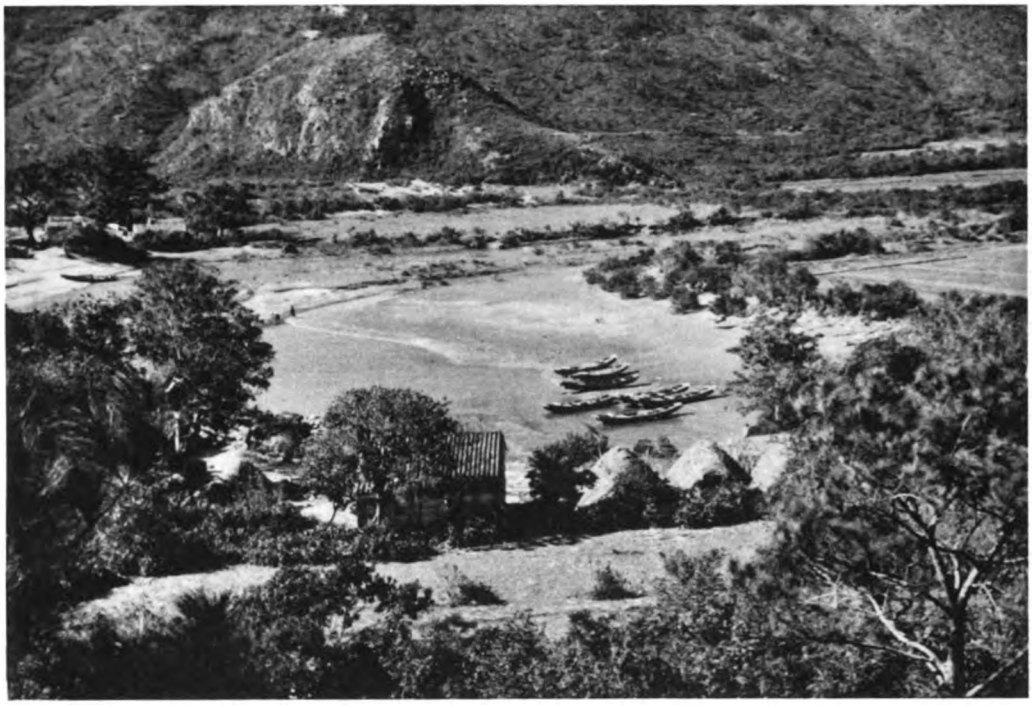
B. Excavation of the Danh Do La site.



Tonkin. Excavating the Dong Mau site.
A. Upper levels.

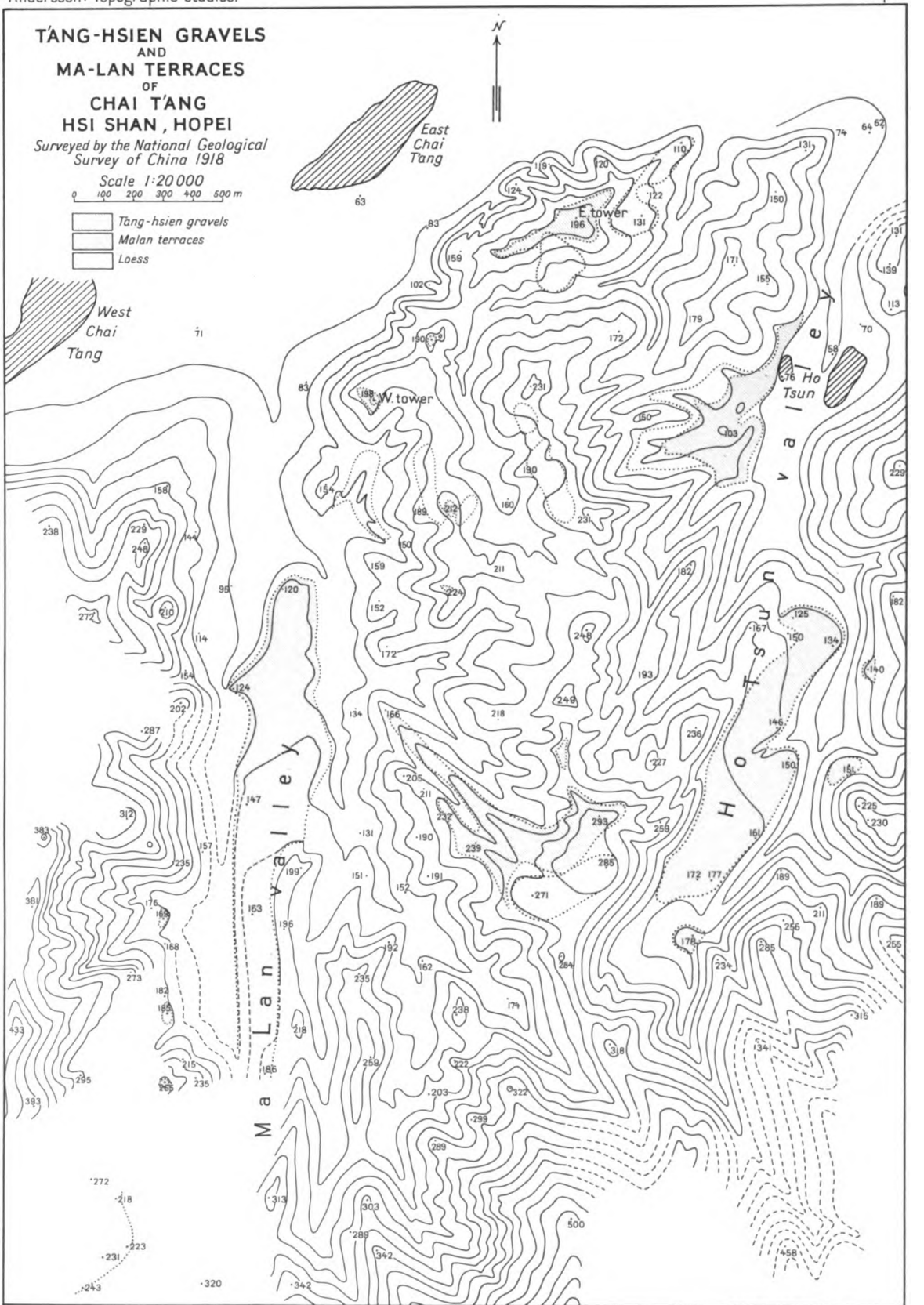
B. Lower levels.

Tonkin. The Xich Tho site. Go-Mien and mangrove flat.



A. Hongkong colony. Lantau Island. Lagoon near the Shek Pek site.

B. Excavating secondary enrichment. Shek Pek Site.

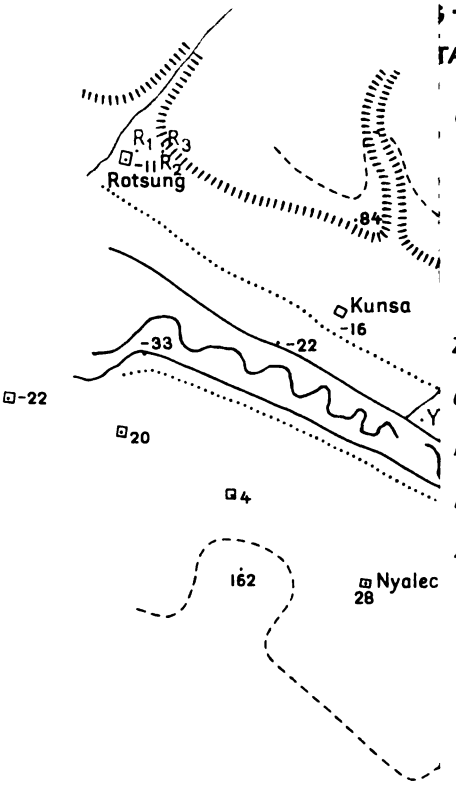


MAP OF THE
-CHOLÖNA TERRACE COMPLEX
TAO FU HSIEN, HSI KANG

Scale 1 : 25 000

0 500 1000 m

Surveyed 3-8 August 1937
by
J. G. Andersson



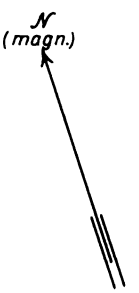
Zerolevel of survey

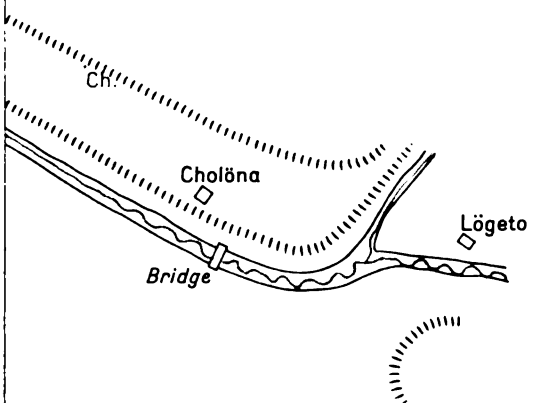
Contour-line of 100 m

Road

Baseline

Archaeological site





GENERALSTABENS LITOGR. ANSTALT, STHLM 1939

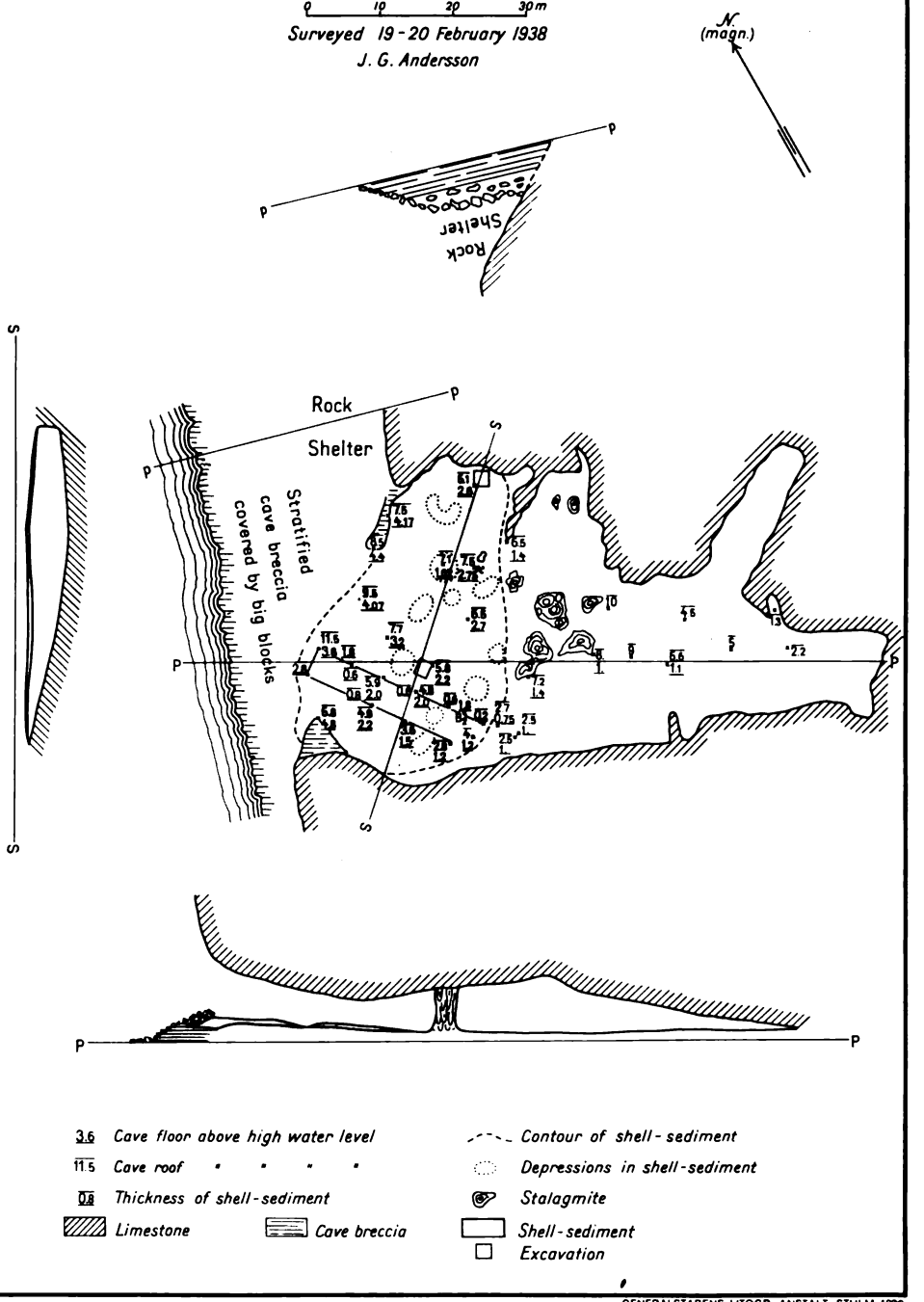
GROTTE DU CISEAU
ILE DES GROTTES

Scale 1:1000

0 10 20 30 m

Surveyed 19-20 February 1938

J. G. Andersson



3.6 *Cave floor above high water level*

11.5 *Cave roof*

0.8 *Thickness of shell-sediment*

Limestone

Cave breccia

Contour of shell-sediment

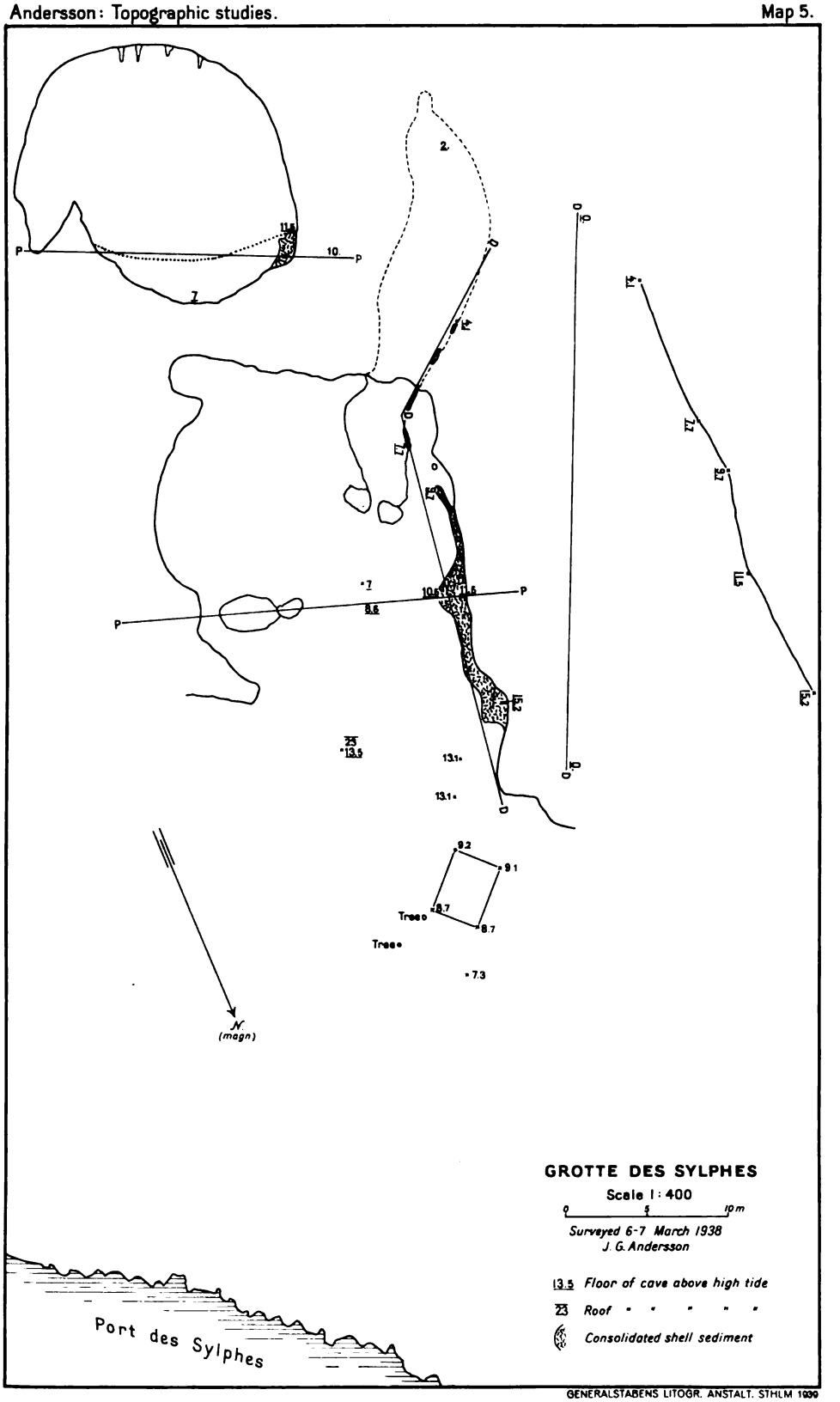
Depressions in shell-sediment

Stalagmite

Shell-sediment

Excavation

GENERALSTABENS LITOGR. ANSTALT. STHLM 1939



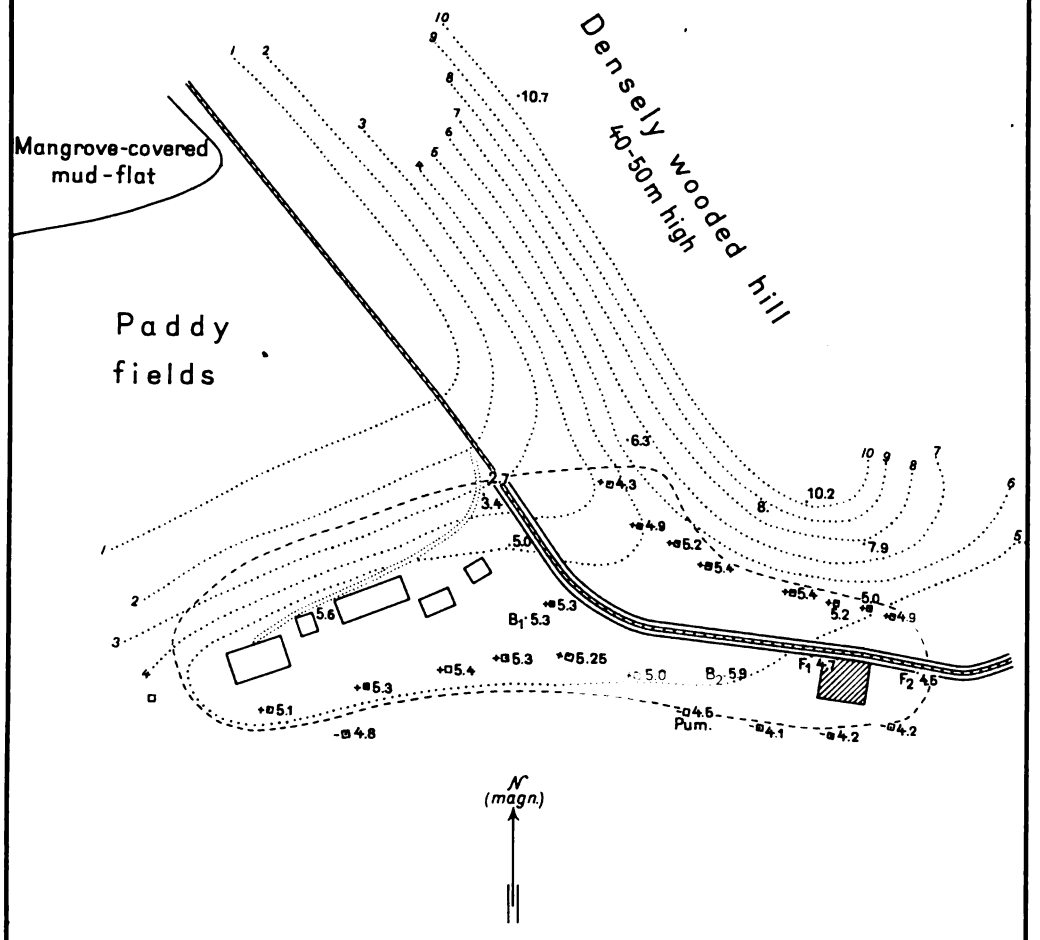
THE DANH DO LA SITE

FAI TSI LONG ARCHIPELAGO, TONKIN

Scale 1:1500

0 10 20 30 40 50 m

Surveyed 15-17 March 1938
J. G. Andersson



Decauville railway
2.5 m deep cut for railway
Contour of site
Experimental digging
Big digging
Contourlines with one meter equidistance

GENERALSTABENS LITOGR. ANSTALT, STHLM 1939

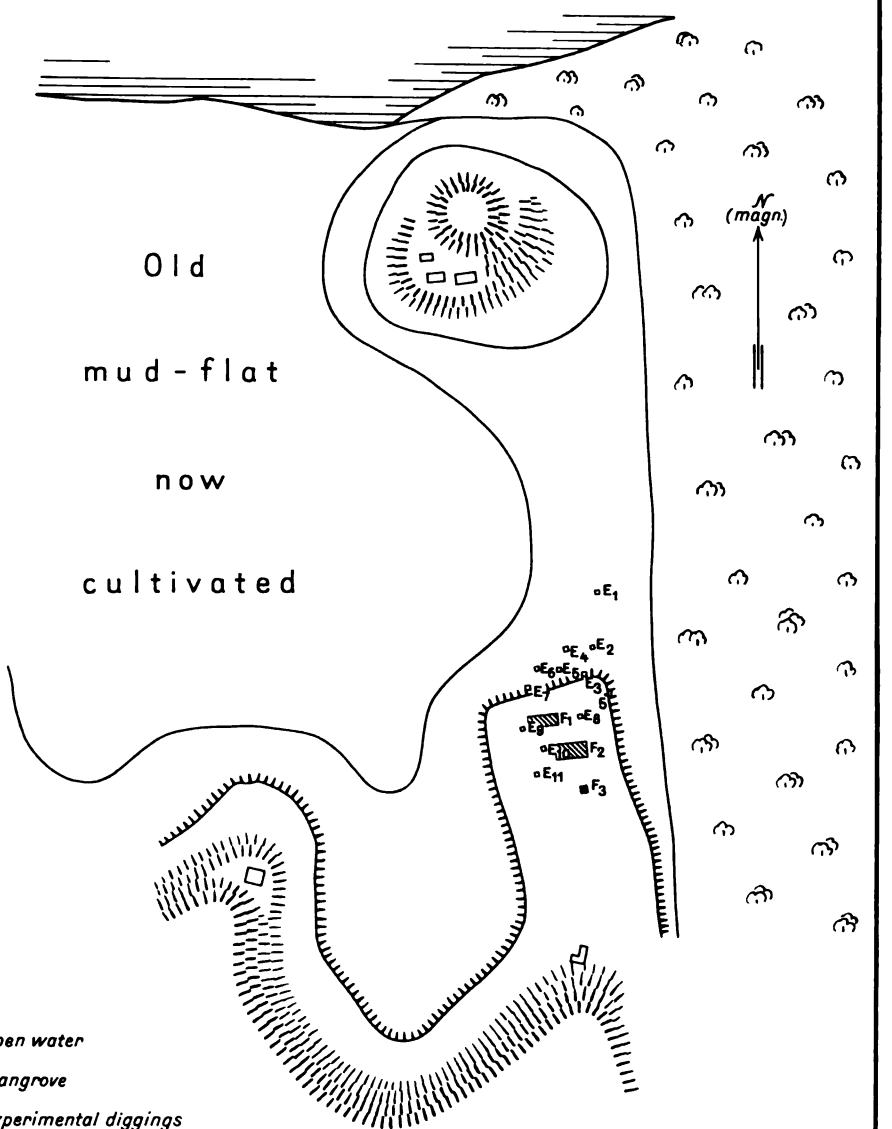
THE DONG MAU SITE

PORT COURBET, TONKIN

Scale 1:3000

0 50 100 m

Surveyed 26.3.1938. J.G.Andersson



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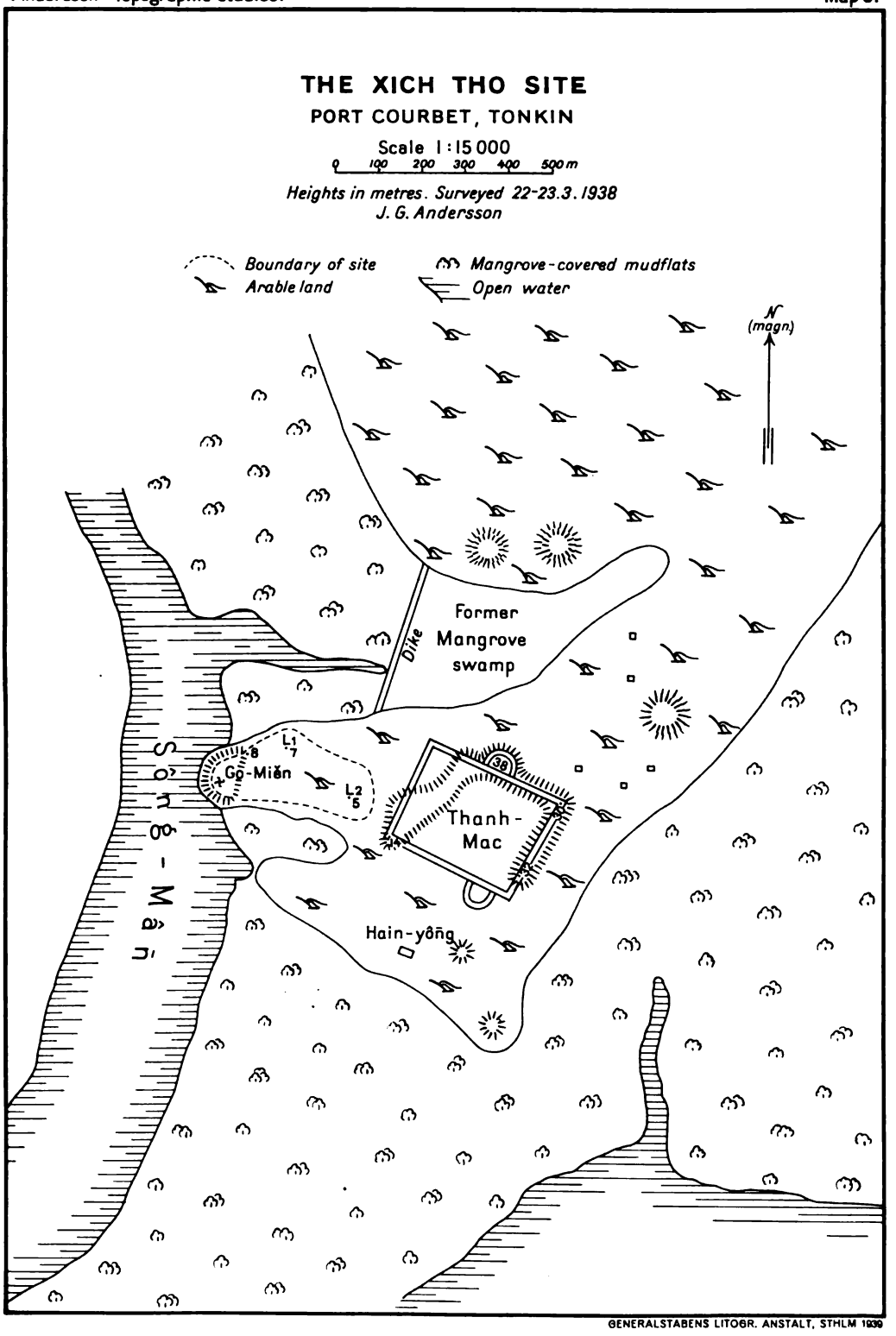


MAP OF THE SHEK PEK SITE

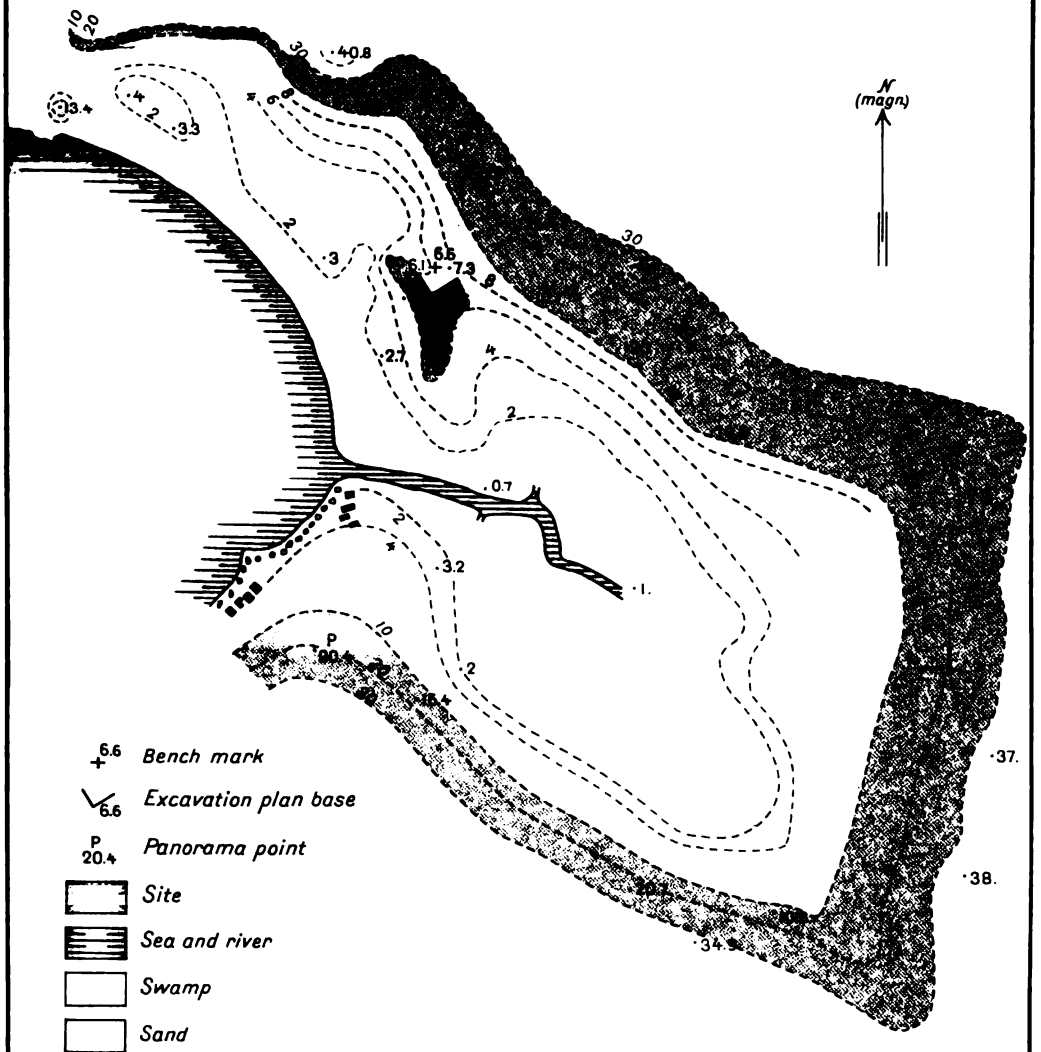
LANTAU ISLAND - HONGKONG COLONY

Scale 1 : 5000

0 50 100 150 200 m

Surveyed 23-24 Jan. 1937

J. G. Andersson



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